

## APPENDIX A – STD & SPEC

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## STD &amp; SPEC 3.01



## SAFETY FENCE

Definition

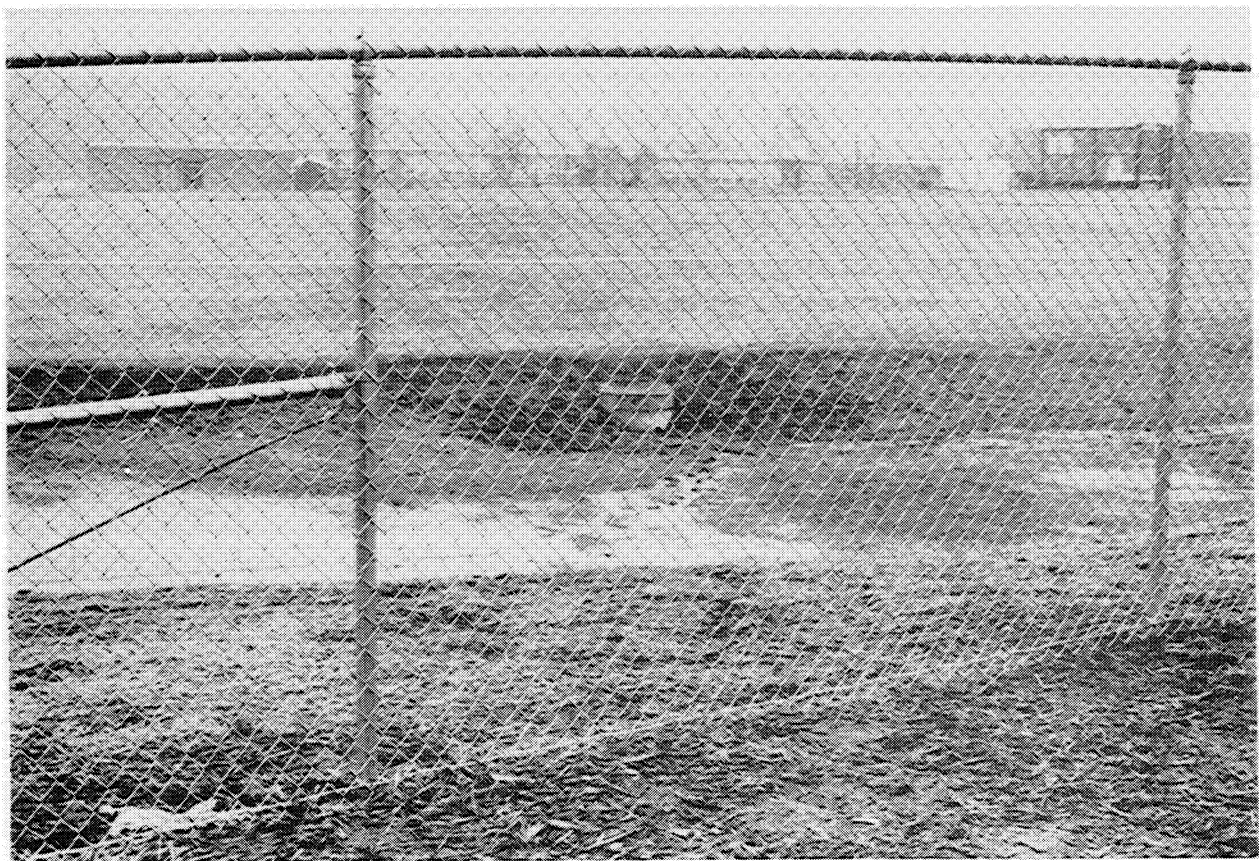
A protective barrier installed to prevent access to an erosion control measure.

Purpose

To prohibit the undesirable use of an erosion control measure by the public.

Conditions Where Practice Applies

Applicable to any control measure or series of measures which can be considered unsafe by virtue of potential for access by the public.



### Planning Considerations

The safety of the public must always be considered at both the planning and implementation phases of a land-disturbing activity. If there is any question concerning the risk of a particular erosion control measure to the general public, the measure should be relocated to a safer area, or an appropriate safety fence should be installed to prevent undesired access. Many times, the danger posed by a control may not be easily seen by plan designers and reviewers - that is when the on-site contractor or inspector must correct such situations in the field. Properly designed and installed safety fences prevent the trespassing of people into potentially dangerous areas, such as children using a sediment basin or a stormwater retention structure as play areas. The installation of these fences will protect people from hazards and the owner from possible litigation.

Two different types of fence will be discussed in this specification. The designer, developer, and contractor should always be sure that the most appropriate type of fence is utilized for a particular need.

### Design Criteria

1. Safety fences should be located so as to create a formidable barrier to undesired access, while allowing for the continuation of necessary construction operations.
2. Safety fences are most applicable to the construction of berms, traps, and dams. In use with those structures, safety fences should be located far enough beyond the outer toe of the embankment to allow for the passage of maintenance vehicles. Fences should not be installed across the slope of a dam or dike.
3. The height of the fence shall be a minimum of 5 feet for plastic fence and 6 feet for metal fence. A fence must never be so short as to become an attraction for children to climb on or over.
4. Signs noting potential hazards such as "DANGER-QUICKSAND" or "HAZARDOUS AREA - KEEP OUT" should be posted and easily seen by anyone approaching the protected area.
5. Plastic (polyethylene) fence may be used as safety fencing, primarily in situations where the need is for a temporary barrier (see Plate 3.01-1). The fence should meet the physical requirements noted in the following table:

TABLE 3.01-A

## PHYSICAL PROPERTIES OF PLASTIC SAFETY FENCE

<u>Physical Property</u>	<u>Test</u>	<u>Requirements</u>
Recommended color	N/A	"International" orange
Tensile yield	ASTM D638	Average 2000 lbs. per 4 ft. width
Ultimate tensile strength	ASTM D638	Average 2900 lbs. per 4 ft. width
Elongation at break(%)	ASTM D638	Greater than 1000%
Chemical resistance	N/A	Inert to most chemicals and acids

Source: Conwed Plastics

6. Metal or "chain-link" fence should be used when a potentially dangerous control measure will remain in place permanently, such as a stormwater detention or retention basin (see Plate 3.01-1). However, they may also be used for measures which will only serve a temporary function, at the discretion of those responsible for project safety. The metal fence must meet the following physical requirements:
- Fabric shall be zinc-coated steel, 2-inch mesh, 9-gauge, minimum.
  - Zinc coating shall have a minimum weight of 1.8 ounces per square foot.
  - Posts shall be steel pipe, zinc-coated.
  - Top nails shall be steel pipe, zinc-coated.
  - Braces shall be made of zinc-coated steel.
  - Gates shall be single or double swing, zinc-coated steel. They shall be a minimum of 12-feet wide.



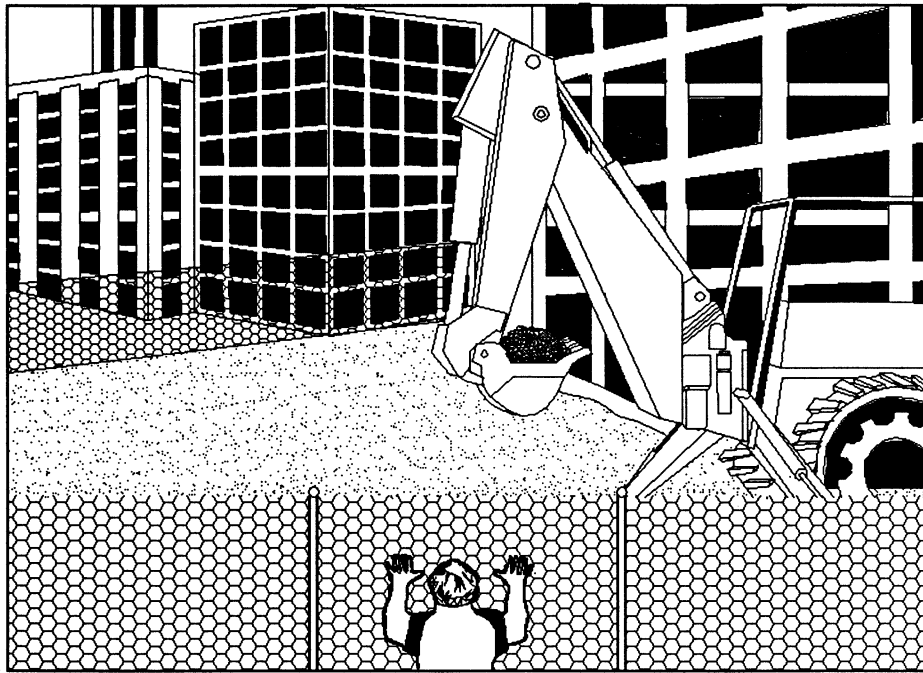
### Construction Specifications

1. Safety fences must be installed prior to the E&S measure becoming accessible.
2. The polyethylene web of the plastic safety fence shall be secured to a conventional metal "T" or "U" post driven into the ground to a minimum depth of 18 inches; posts should be spaced at 6-foot centers. See "perspective" view in Plate 3.01-1.
3. The metal safety fence shall be installed as per the following procedure:
  - a. Line posts shall be placed at intervals of 10 feet measured from center to center of adjacent posts. In determining the post spacing, measurement will be made parallel with the ground surface. See "perspective" view in Plate 3.01-1.
  - b. Posts will be set in concrete and backfilled or anchored by other acceptable means.
  - c. Posts set in the tops of concrete walls shall be grouted into preformed holes to a minimum depth of 12 inches.
  - d. All corner posts, end posts, gate posts, and pull posts shall be embedded, braced, and trussed as shown in the "Standard Fence - Chain Link" detail found in the latest version of the Virginia Department of Transportation (VDOT) Road and Bridge Standards.
  - e. Fencing fabric shall not be stretched until at least 4 days after the posts are grouted into walls or 14 days after the posts are set into concrete.
  - f. The fabric shall be stretched taut and securely fastened, by means of tie clips, to the posts at intervals not exceeding 15 inches and to the top rails or tension wires at intervals not exceeding 2 feet. Care shall be taken to equalize the tension on each side of each post.
4. Applicable warning signs noting hazardous conditions must be installed immediately upon installation of safety fence.

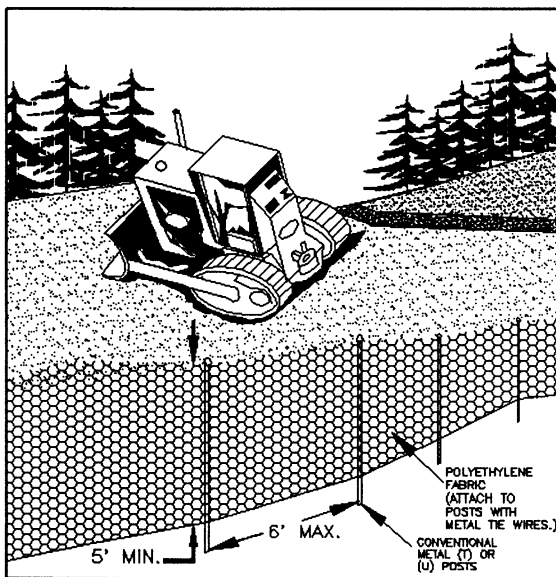
### Maintenance

1. Safety fence shall be checked regularly for weather-related or other damage. Any necessary repairs must be made immediately.
2. Care should be taken to secure all access points (gates) at the end of each working day. All locking devices must be repaired or replaced as necessary.

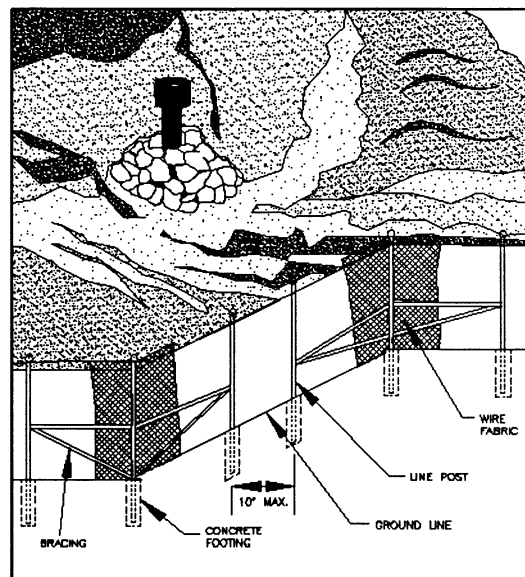
## SAFETY FENCE



PERSPECTIVE VIEW



PERSPECTIVE VIEW  
PLASTIC FENCE



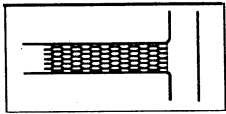
PERSPECTIVE VIEW  
METAL FENCE

Source: Adapted from Conwed Plastics and  
VDOT Road and Bridge Standards

Plate 3.01-1

## STD &amp; SPEC 3.02

## TEMPORARY STONE CONSTRUCTION ENTRANCE



### Definition

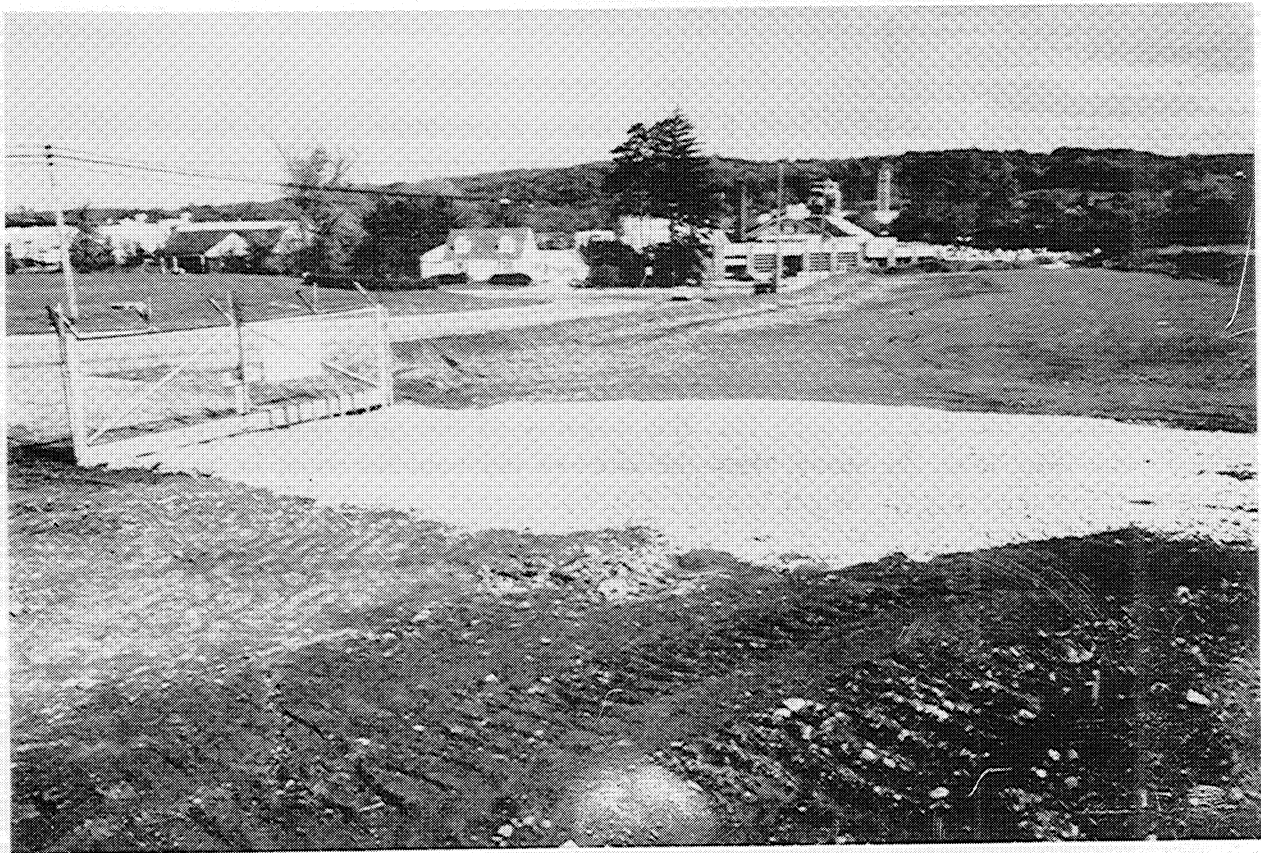
A stabilized stone pad with a filter fabric underliner located at points of vehicular ingress and egress on a construction site.

### Purpose

To reduce the amount of mud transported onto paved public roads by motor vehicles or runoff.

### Conditions Where Practice Applies

Wherever traffic will be leaving a construction site and move directly onto a public road or other paved area.



### Planning Considerations

Minimum Standard #17 (MS #17) requires that provisions be made to minimize the transport of sediment by vehicular traffic onto a paved surface. Construction entrances provide an area where a significant amount of mud can be removed from construction vehicle tires before they enter a public road and, just as important, the soil adjacent to the paved surface can be kept intact. A filter fabric liner is used as a "separator" to minimize the dissipation of aggregate into the underlying soil due to construction traffic loads. If the action of the vehicles traveling over the gravel pad is not sufficient to remove the majority of the mud or there exists an especially sensitive traffic situation on the adjacent paved road, the tires must be washed before the vehicle enters the public road. If washing is necessary, provisions must be made to intercept the wash water and trap the sediment so it can be collected and stabilized. Construction entrances should be used in conjunction with the stabilization of construction roads (see Std. & Spec. 3.03, CONSTRUCTION ROAD STABILIZATION) to reduce the amount of mud picked up by construction vehicles and to do a better job of mud removal. Other innovative techniques for accomplishing the same purpose (such as a bituminous entrance) can be utilized, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

### Design Criteria

#### Aggregate Size

VDOT #1 Coarse Aggregate (2- to 3-inch stone) should be used.

#### Entrance Dimensions

The aggregate layer must be at least 6 inches thick; a minimum three inches of aggregate should be placed in a cut section to give the entrance added stability and to help secure filter cloth separator. It must extend the full width of the vehicular ingress and egress area and have a minimum 12-foot width. The length of the entrance must be at least 70 feet (see Plate 3.02-1).

#### Washing

If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the stone, then the tires of the vehicles must be washed before entering the public road. Wash water must be carried away from the entrance to a approved settling area to remove sediment. All sediment shall be prevented from entering storm drains, ditches, or watercourses. A wash rack may also be used to make washing more convenient and effective (see Plate 3.02-1).

#### Location

The entrance should be located to provide for maximum utilization by all construction vehicles.

### Construction Specifications

The area of the entrance must be excavated a minimum of 3 inches and must be cleared of all vegetation, roots, and other objectionable material. The filter fabric underliner will then be placed the full width and length of the entrance.

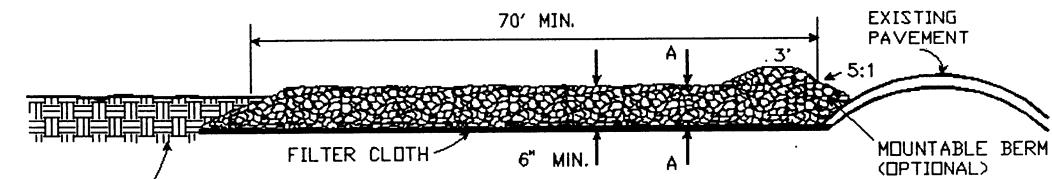
Following the installation of the filter cloth, the stone shall be placed to the specified dimensions. If wash racks are used, they should be installed according to manufacturer's specifications. Any drainage facilities required because of washing should be constructed according to specifications. Conveyance of surface water under entrance, through culverts, shall be provided as required. If such conveyance is impossible, the construction of a "mountable" berm with 5:1 slopes will be permitted.

The filter cloth utilized shall be a woven or nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals and hydrocarbons, be mildew and rot resistant, and conform to the physical properties noted in Table 3.02-A.

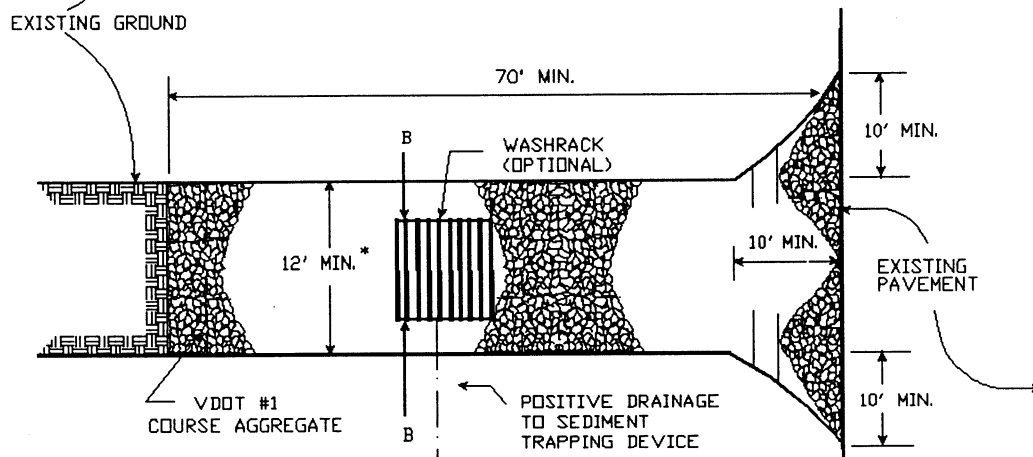
### Maintenance

The entrance shall be maintained in a condition which will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with additional stone or the washing and reworking of existing stone as conditions demand and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately. The use of water trucks to remove materials dropped, washed, or tracked onto roadways will not be permitted under any circumstances.

# STONE CONSTRUCTION ENTRANCE

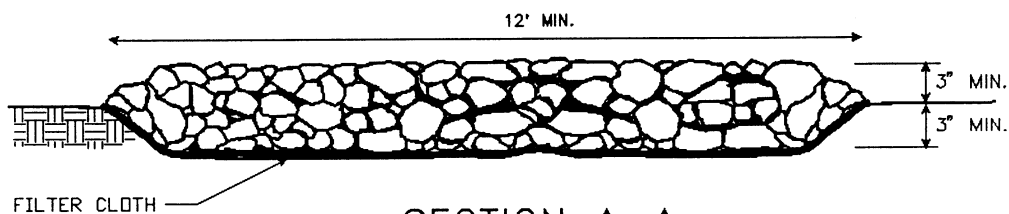


## SIDE ELEVATION

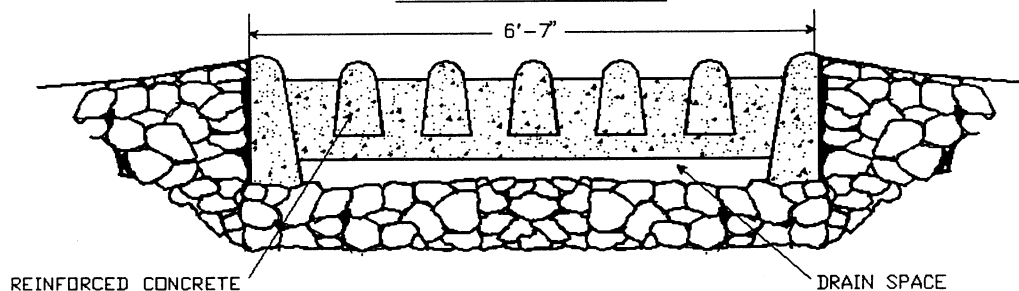


\* MUST EXTEND FULL WIDTH OF INGRESS AND EGRESS OPERATION

## PLAN VIEW



## SECTION A-A



## SECTION B-B

Source: Adapted from 1983 Maryland Standards for Soil Erosion and Sediment Control, and Va. DSWC

Plate 3.02-1

**TABLE 3.02-A**  
**CONSTRUCTION SPECIFICATIONS**  
**FOR FILTER CLOTH UNDERLINER**

<u>Fabric Properties<sup>1</sup></u>	<u>Light-Duty Entrance<sup>2</sup></u> <u>(Graded Subgrade)</u>	<u>Heavy-Duty Entrance<sup>3</sup></u> <u>(Rough Graded)</u>	<u>Test Method</u>
Grab Tensile Strength (lbs.)	200	220	ASTM D1682
Elongation at Failure (%)	50	220	ASTM D1682
Mullen Burst Strength (lbs.)	190	430	ASTM D3786
Puncture Strength (lbs.)	40	125	ASTM D751 (modified)
Equivalent Opening Size (mm)	40-80	40-80	U.S. Standard Sieve CW-02215

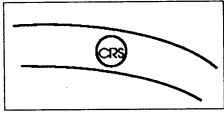
<sup>1</sup> Fabrics not meeting these specifications may be used only when design procedure and supporting documentation are supplied to determine aggregate depth and fabric strength.

<sup>2</sup> Light Duty Entrance: Sites that have been graded to subgrade and where most travel would be single axle vehicles and an occasional multi-axle truck. Examples of fabrics which can be used are: Trevira Spunbond 1115, Mirafi 100X, Typar 3401, or equivalent.

<sup>3</sup> Heavy Duty Entrance: Sites with only rough grading and where most travel would be multi-axle vehicles. Examples of fabrics which can be used are: Trevira Spunbond 1135, Mirafi 600X, or equivalent.

Source: Virginia Highway and Transportation Research Council (VHTRC)

## STD &amp; SPEC 3.03

CONSTRUCTION ROAD  
STABILIZATIONDefinition

The temporary stabilization of access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes with stone immediately after grading.

Purposes

1. To reduce the erosion of temporary roadbeds by construction traffic during wet weather.
2. To reduce the erosion and subsequent regrading of permanent roadbeds between the time of initial grading and final stabilization.

Conditions Where Practice Applies

Wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.





### Planning Considerations

Areas which are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires which generate significant quantities of sediment that may pollute nearby streams or be transported off site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Immediate stabilization of such areas with stone may cost money at the outset, but it may actually save money in the long run by increasing the usefulness of the road during wet weather.

Permanent roads and parking areas should be paved as soon as possible after grading. However, it is understandable that weather conditions or the potential for damage may not make paving feasible in the early phases of the development project. As an alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course in the construction of the road.

### Specifications

#### Temporary Access Roads and Parking Areas

1. Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes should not exceed 10 percent.
2. Temporary parking areas should be located on naturally flat areas to minimize grading. Grades should be sufficient to provide drainage but should not exceed 4 percent.
3. Roadbeds shall be at least 14 feet wide for one-way traffic and 20 feet wide for two-way traffic.
4. All cuts and fills shall be 2:1 or flatter to the extent possible.
5. Drainage ditches shall be provided as needed and shall be designed and constructed in accordance with STORMWATER CONVEYANCE CHANNEL, Std. & Spec. 3.17.
6. The roadbed or parking surface shall be cleared of all vegetation, roots and other objectionable material.

7. A 6-inch course of VDOT #1 Coarse Aggregate shall be applied immediately after grading or the completion of utility installation within the right-of-way. Filter fabric may be applied to the roadbed for additional stability. Design specifications for filter fabric can be found within Std. & Spec. 3.02, TEMPORARY STONE CONSTRUCTION ENTRANCE. In "heavy duty" traffic situations (see Table 3.02-A), stone should be placed at an 8- to 10-inch depth to avoid excessive dissipation or maintenance needs.

#### Permanent Roads and Parking Areas

Permanent roads and parking areas shall be designed and constructed in accordance with applicable VDOT or local criteria except that an initial base course of gravel of at least 6 inches shall be applied immediately following grading.

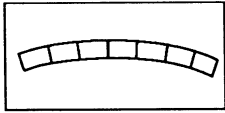
#### Vegetation

All roadside ditches, cuts, fills and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation according to the applicable standards and specifications contained in this handbook.

#### Maintenance

Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. Seeded areas adjacent to the roads and parking areas should be checked periodically to ensure that a vigorous stand of vegetation is maintained. Roadside ditches and other drainage structures should be checked regularly to ensure that they do not become clogged with silt or other debris.

## STD &amp; SPEC 3.04



## STRAW BALE BARRIER

Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to prevent sediment from leaving the construction site.
2. To decrease the velocity of sheet flows.



### Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion.
2. Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (2:1).
3. Where effectiveness is required for less than 3 months.
4. Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.
5. The measure should not be used where water may concentrate in defined ditches and minor swales.
6. Straw bale barriers shall not be used on areas where rock or another hard surface prevents the full and uniform anchoring of the barrier.

### Planning Considerations

Based on observations made in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be - especially when used to slow down and filter concentrated flows. They should be used judiciously and with caution as erosion control measures. There are three major reasons for such ineffectiveness.

First, improper utilization of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water depth and velocities have destroyed or damaged the control. Secondly, improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions of, rather than removal of, sediment from runoff waters. Finally, inadequate maintenance lowers the effectiveness of these barriers. Trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57% to 16% in one month due to lack of maintenance.

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging from \$3 to \$6 per linear foot, the thousands of straw bale barriers used annually in Virginia represent such a considerable expense that optimum installation procedures should be emphasized.

### Design Criteria

A formal design is not required. However, an effort should be made to locate the straw bale barrier, as well as other perimeter controls, at least 5 to 7 feet from the base of disturbed slopes with grades greater than 7%. This will help prevent the measure from being rendered useless following the initial movement of soil.

### Construction Specifications

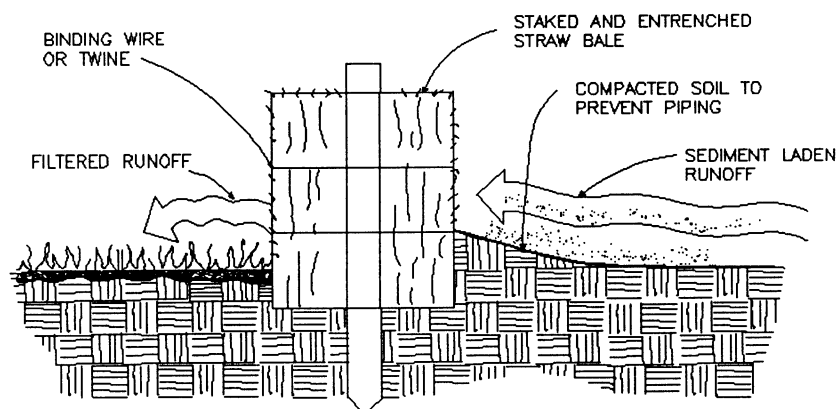
#### Sheet Flow Application

1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.
2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings (see Plate 3.04-1).
3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked and chinked (gaps filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier (see Plate 3.04-1).
4. Each bale shall be securely anchored by at least two stakes (minimum dimensions 2 inches x 2 inches x 36 inches) or standard "T" or "U" steel posts (minimum weight of 1.33 pounds per linear foot) driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 18 inches deep into the ground to securely anchor the bales.
5. The gaps between bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency.
6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.
7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

Maintenance

1. Straw bale barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall.
2. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.
3. Necessary repairs to barriers or replacement of bales shall be accomplished promptly.
4. Sediment deposits should be removed after each rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.
5. Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.

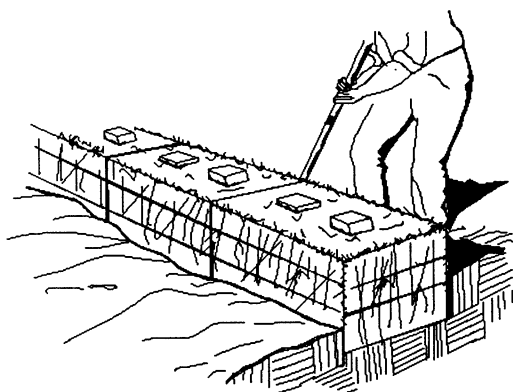
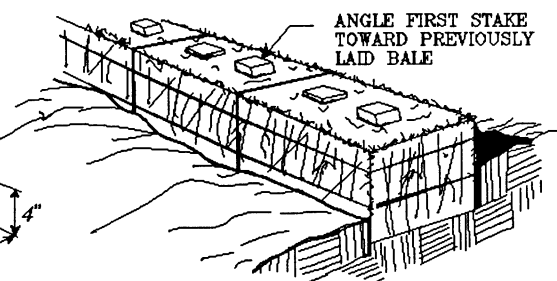
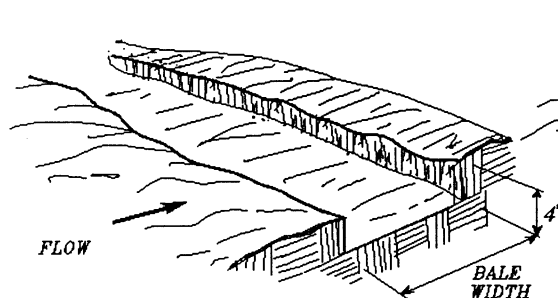
# STRAW BALE BARRIER



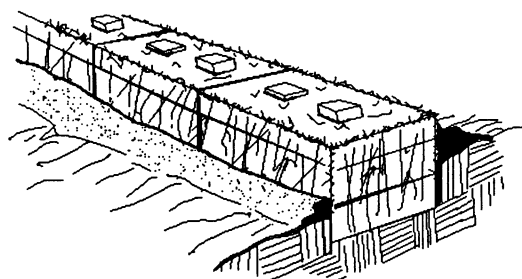
PROPERLY INSTALLED STRAW BALE  
(CROSS SECTION)

1. EXCAVATE THE TRENCH.

2. PLACE AND STAKE STRAW BALES.



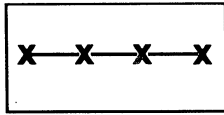
3. WEDGE LOOSE STRAW BETWEEN BALES.



4. BACKFILL AND COMPACT THE  
EXCAVATED SOIL.

## CONSTRUCTION OF STRAW BALE BARRIER

## STD &amp; SPEC 3.05



## SILT FENCE

Definition

A temporary sediment barrier consisting of a synthetic filter fabric stretched across and attached to supporting posts and entrenched.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.
2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.





### Conditions Where Practice Applies

1. Below disturbed areas where erosion would occur in the form of sheet and rill erosion.
2. Where the size of the drainage area is no more than one quarter acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2:1).
3. In minor swales or ditch lines where the maximum contributing drainage area is no greater than 1 acre and flow is no greater than 1 cfs.
4. Silt fence will not be used in areas where rock or some other hard surface prevents the full and uniform depth anchoring of the barrier.

### Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council (VHTRC) has shown that silt fences can trap a much higher percentage of suspended sediments than straw bales, though silt fence passes the sediment-laden water slower. Silt fences are preferable to straw barriers in many cases because of their durability and potential cost savings. While the failure rate of silt fences is lower than that of straw barriers, many instances have been observed where silt fences are improperly installed, inviting failure and sediment loss. The installation methods outlined here can improve performance and reduce failures.

As noted, flow rate through silt fence is significantly lower than the flow rate for straw bale barriers. This creates more ponding and hence more time for sediment to fall out. Table 3.05-A demonstrates these relationships.

Both woven and non-woven synthetic fabrics are commercially available. The woven fabrics generally display higher strength than the non-woven fabrics and, in most cases, do not require any additional reinforcement. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength, while the reactions of non-woven fabrics to these conditions are variable. The same is true of testing under extensive ultraviolet radiation. Permeability rates vary regardless of fabric type. While all of the fabrics demonstrate very high filtering efficiencies for sandy sediments, there is considerable variation among both woven and non-woven fabrics when filtering the finer silt and clay particles.

### Design Criteria

1. No formal design is required. As with straw bale barriers, an effort should be made to locate silt fence at least 5 feet to 7 feet beyond the base of disturbed slopes with grades greater than 7%.

TABLE 3.05-A

**TYPICAL FLOW RATES AND FILTERING  
EFFICIENCIES OF PERIMETER CONTROL**

<u>Material</u>	<u>Flow Rate (gal./sq.ft./min)</u>	<u>Filter Efficiency(%)</u>
Straw	5.6	67
Synthetic Fabric	0.3	97

Source: VHTRC

2. The use of silt fences, because they have such a low permeability, is limited to situations in which only sheet or overland flows are expected and where concentrated flows originate from drainage areas of 1 acre or less.
3. Field experience has demonstrated that, in many instances, silt fence is installed too short (less than 16 inches above ground elevation). The short fence is subject to breaching during even small storm events and will require maintenance "clean outs" more often. Properly supported silt fence which stands 24 to 34 inches above the existing grade tends to promote more effective sediment control.

Construction Specifications

Materials

1. Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester or ethylene yarn and shall be certified by the manufacturer or supplier as conforming to the requirements noted in Table 3.05-B.
2. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0° F to 120° F.
3. If wooden stakes are utilized for silt fence construction, they must have a diameter of 2 inches when oak is used and 4 inches when pine is used. Wooden stakes must have a minimum length of 5 feet.

**TABLE 3.05-B**  
**PHYSICAL PROPERTIES OF**  
**FILTER FABRIC IN SILT FENCE**

<u>Physical Property</u>	<u>Test</u>	<u>Requirements</u>
Filtering Efficiency	ASTM 5141	75% (minimum)
Tensile Strength at 20% (max.) Elongation*	VTM-52	Extra Strength - 50 lbs./linear inch (minimum)  Standard Strength - 30 lbs./linear inch (minimum)
Flow Rate	ASTM 5141	0.2 gal./sq.ft./ minute (minimum)
Ultraviolet Radiation Stability %	ASTM-G-26	90% (minimum)

\* Requirements reduced by 50% after six months of installation.

Source: VHTRC

4. If steel posts (standard "U" or "T" section) are utilized for silt fence construction, they must have a minimum weight of 1.33 pounds per linear foot and shall have a minimum length of 5 feet.
5. Wire fence reinforcement for silt fences using standard-strength filter cloth shall be a minimum of 14 gauge and shall have a maximum mesh spacing of 6 inches.

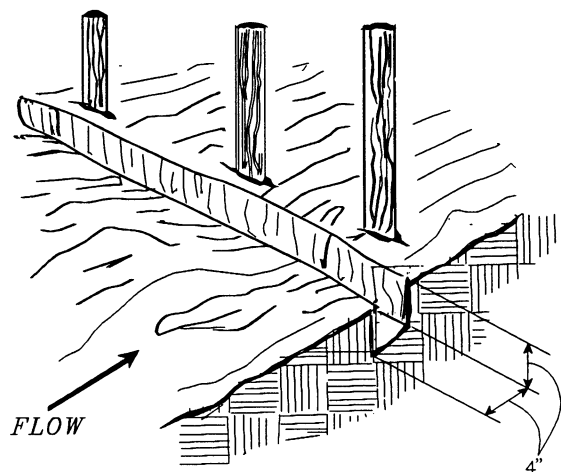
#### Installation

1. The height of a silt fence shall be a minimum of 16 inches above the original ground surface and shall not exceed 34 inches above ground elevation.

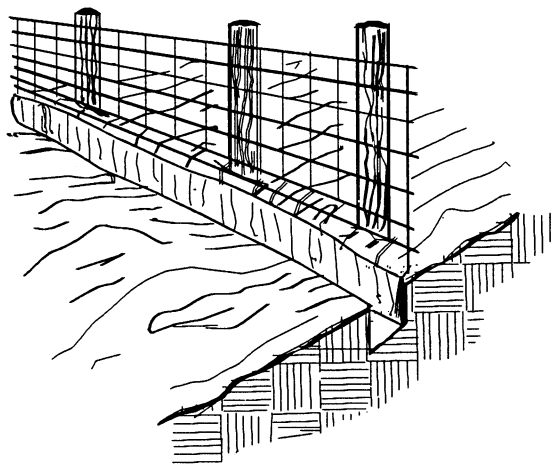
2. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.
3. A trench shall be excavated approximately 4-inches wide and 4-inches deep on the upslope side of the proposed location of the measure.
4. When wire support is used, standard-strength filter cloth may be used. Posts for this type of installation shall be placed a maximum of 10-feet apart (see Plate 3.05-1). The wire mesh fence must be fastened securely to the upslope side of the posts using heavy duty wire staples at least one inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of two inches and shall not extend more than 34 inches above the original ground surface. The standard-strength fabric shall be stapled or wired to the wire fence, and 8 inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees.
5. When wire support is not used, extra-strength filter cloth shall be used. Posts for this type of fabric shall be placed a maximum of 6-feet apart (see Plate 3.05-2). The filter fabric shall be fastened securely to the upslope side of the posts using one inch long (minimum) heavy-duty wire staples or tie wires and eight inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees. This method of installation has been found to be more commonplace than #4.
6. If a silt fence is to be constructed across a ditch line or swale, the measure must be of sufficient length to eliminate endflow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope (see Plate 3.05-2). Extra-strength filter fabric shall be used for this application with a maximum 3-foot spacing of posts.  
  
All other installation requirements noted in #5 apply.
7. The 4-inch by 4-inch trench shall be backfilled and the soil compacted over the filter fabric.
8. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

## CONSTRUCTION OF A SILT FENCE (WITH WIRE SUPPORT)

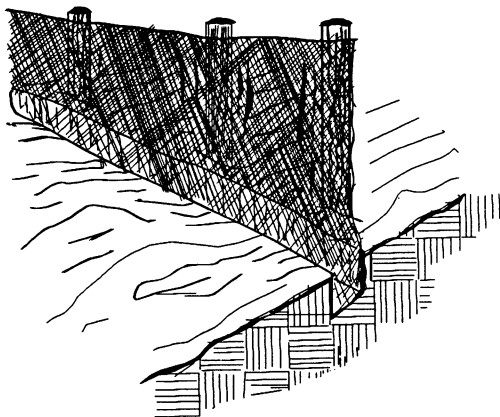
1. SET POSTS AND EXCAVATE A 4"X4" TRENCH UPSLOPE ALONG THE LINE OF POSTS.



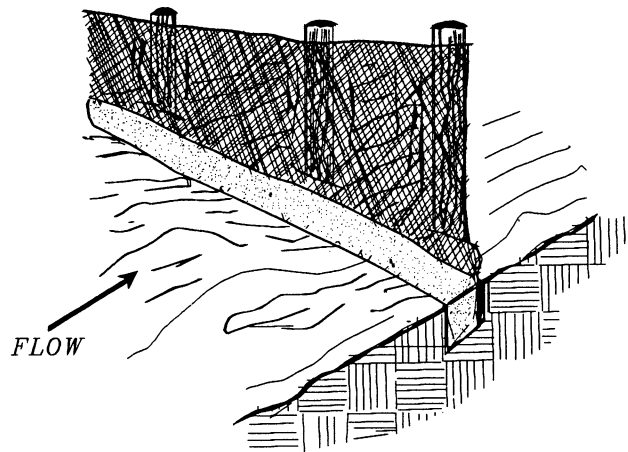
2. STAPLE WIRE FENCING TO THE POSTS.



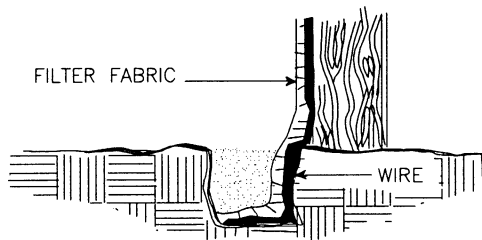
3. ATTACH THE FILTER FABRIC TO THE WIRE FENCE AND EXTEND IT INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



EXTENSION OF FABRIC AND WIRE INTO THE TRENCH.

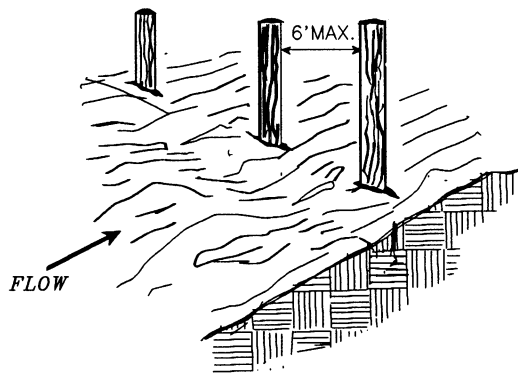


Source: Adapted from Installation of Straw and Fabric Filter Barriers for Sediment Control, Sherwood and Wyant

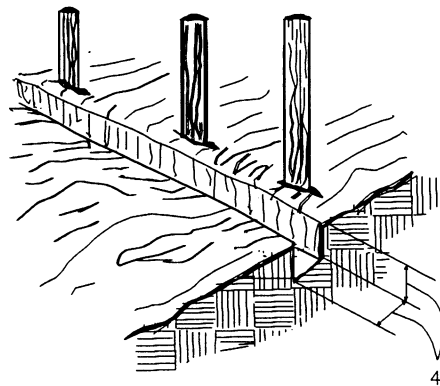
Plate 3.05-1

## CONSTRUCTION OF A SILT FENCE (WITHOUT WIRE SUPPORT)

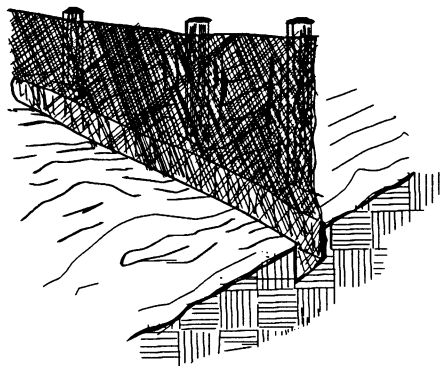
1. SET THE STAKES.



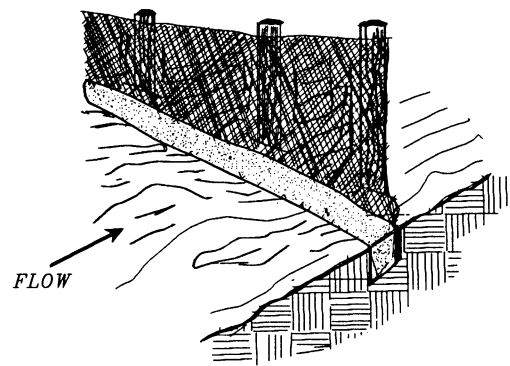
2. EXCAVATE A 4" X 4" TRENCH UPSLOPE ALONG THE LINE OF STAKES.



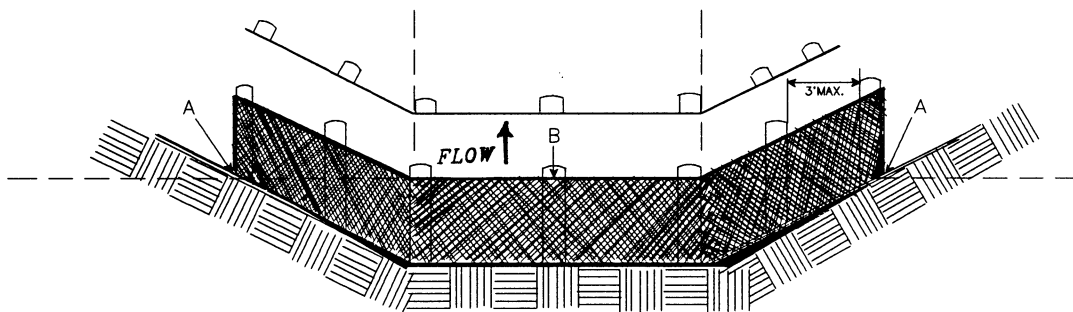
3. STAPLE FILTER MATERIAL TO STAKES AND EXTEND IT INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



SHEET FLOW INSTALLATION  
(PERSPECTIVE VIEW)



POINTS A SHOULD BE HIGHER THAN POINT B.

DRAINAGEWAY INSTALLATION  
(FRONT ELEVATION)

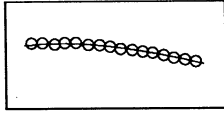
Source: Adapted from Installation of Straw and Fabric Filter Barriers for Sediment Control, Sherwood and Wyant

Plate 3.05-2

Maintenance

1. Silt fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.
2. Close attention shall be paid to the repair of damaged silt fence resulting from end runs and undercutting.
3. Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life and the barrier still be necessary, the fabric shall be replaced promptly.
4. Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately one-half the height of the barrier.
5. Any sediment deposits remaining in place after the silt fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

## STD &amp; SPEC 3.06



## BRUSH BARRIER

Definition

A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from clearing and grubbing the site.

Purpose

To intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.





### Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier.
2. Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (2:1).

### Planning Considerations

Organic litter and spoil material from site clearing operations is usually burned or hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation and root mat along with minor amounts of rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small. Field experience has shown, however, that many brush barrier installations are not effective when there are large voids created by the use of material which is too large (such as tree stumps) to provide a compact, dense barrier. Therefore, it is necessary to use residual material under 6 inches in diameter which will create a more uniform barrier or utilize a filter fabric overlay to promote enhanced filtration of sediment-laden runoff.

### Design Criteria

A formal design is not required.

### Construction Specifications

#### Without Filter Cloth

1. The height of a brush barrier shall be a minimum of 3 feet.
2. The width of a brush barrier shall be a minimum of 5 feet at its base (the sizes of brush barriers may vary considerably based upon the amount of material available and the judgement of the design engineer).
3. The barrier shall be constructed by piling brush, stone, root mat and other material from the clearing process into a mounded row on the contour. Material larger than 6 inches in diameter should not be used to create the mound as the non-homogeneity of the mixture can lead to voids where sediment-laden flows can easily pass.

If a Filter is Used (see Plate 3.06-1)

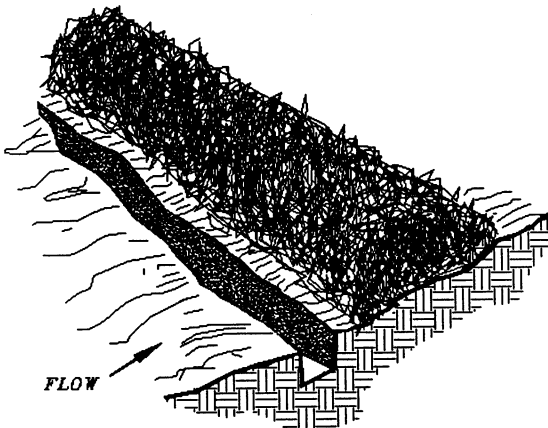
1. Filter fabric must meet the minimum physical requirements noted in Table 3.05-B.
2. The filter fabric shall be cut into lengths sufficient to lay across the barrier from its up-slope base to just beyond its peak. Where joints are necessary, the fabric shall be spliced together with a minimum 6-inch overlap and securely sealed.
3. A trench shall be excavated 6-inches wide and 4-inches deep along the length of the barrier and immediately uphill from the barrier.
4. The lengths of filter fabric shall be draped across the width of the barrier with the uphill edge placed in the trench and the edges of adjacent pieces overlapping each other.
5. The filter fabric shall be secured in the trench with stakes set approximately 36 inches on center.
6. The trench shall be backfilled and the soil compacted over the filter fabric.
7. Set stakes into the ground along the downhill edge of the brush barrier, and anchor the fabric by tying twine from the fabric to the stakes.

Maintenance

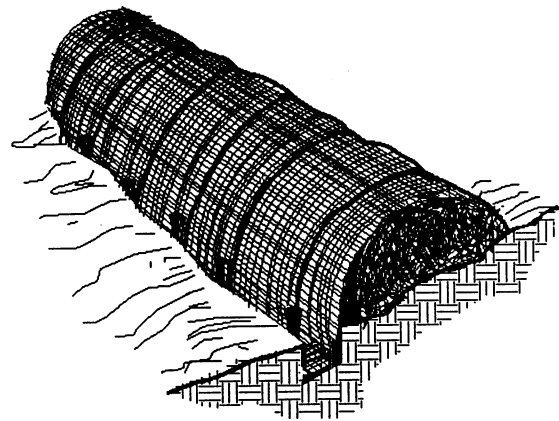
1. Brush barriers shall be inspected after each rainfall and necessary repairs shall be made promptly.
2. Sediment deposits must be removed when they reach approximately one-half the height of the barrier.

# CONSTRUCTION OF A BRUSH BARRIER COVERED BY FILTER FABRIC

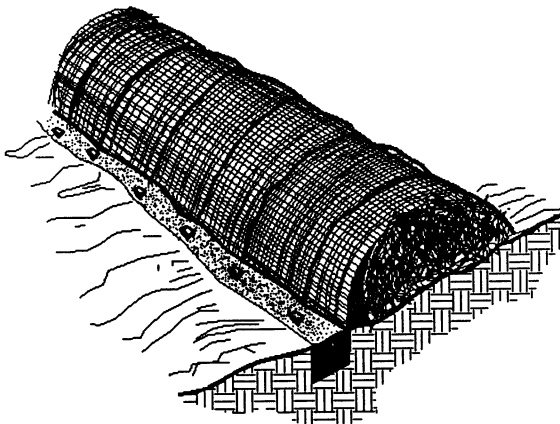
(TREE/RESIDUAL MATERIAL  
WITH DIAMETER > 6")



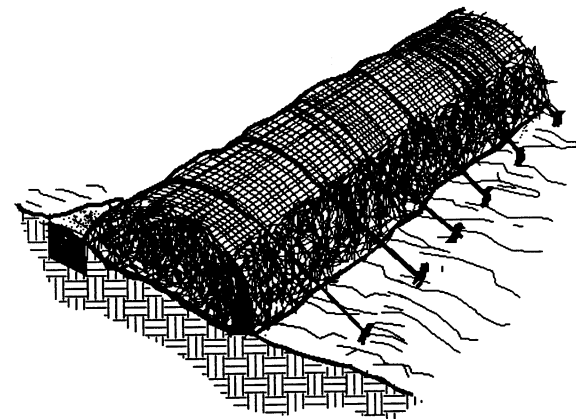
1. EXCAVATE A 4"X 4" TRENCH ALONG THE UPHILL EDGE OF THE BRUSH BARRIER.



2. DRAPE FILTER FABRIC OVER THE BRUSH BARRIER AND INTO THE TRENCH. FABRIC SHOULD BE SECURED IN THE TRENCH WITH STAKES SET APPROXIMATELY 36" O.C.



3. BACKFILL AND COMPACT THE EXCAVATED SOIL.

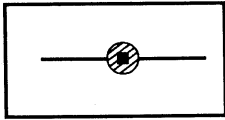


4. SET STAKES ALONG THE DOWN-HILL EDGE OF THE BRUSH BARRIER, AND ANCHOR BY TYING TWINE FROM THE FABRIC TO THE STAKES.

Source: Va. DSWC

Plate 3.06-1

## STD &amp; SPEC 3.07

STORM DRAIN  
INLET PROTECTIONDefinition

A sediment filter or an excavated impounding area around a storm drain drop inlet or curb inlet.

Purpose

To prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

Conditions Where Practice Applies

Where storm drain inlets are to be made operational before permanent stabilization of the corresponding disturbed drainage area. Different types of structures are applicable to different conditions (see Plates 3.07-1 through 3.07-8).



### Planning Considerations

Storm sewers which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the storm sewer itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

This practice contains several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Care should be taken when choosing a specific type of inlet protection. Field experience has shown that inlet protection which causes excessive ponding in an area of high construction activity may become so inconvenient that it is removed or bypassed, thus transmitting sediment-laden flows unchecked. In such situations, a structure with an adequate overflow mechanism should be utilized.

The following inlet protection devices are for drainage areas of one acre or less. Runoff from larger disturbed areas should be routed to a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) or a TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14).

The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Stone is utilized as the chief ponding/filtering agent in most of the inlet protection types described in this specification. The various types of "coarse aggregates" which are depicted are able to filter out sediment mainly through slowing down flows directed to the inlet by creating an increased flow path for the stormwater (through void space in the respective stone). The stone filtering medium by no means slows stormwater flowrate as does filter cloth and therefore cannot provide the same degree of filter efficiency when smaller silt and clay particles are introduced into stormwater flows. However, as mentioned earlier, excessive ponding in busy areas adjacent to stormwater inlets is in many cases unacceptable - that is why stone must be utilized with many installations.

Fortunately, in most instances, inlet protection utilizing stone should not be the sole control measure. At the time that storm sewer inlet and associated appurtenances become operational, areas adjacent to the structures are most likely at final grade or will not be altered for extended periods; this is the time when TEMPORARY SEEDING (Std. & Spec. 3.31) and other appropriate controls should be implemented to enhance sediment-loss mitigation. In addition, by varying stone sizes used in the construction of inlet protection, a greater degree of sediment removal can be obtained. As an option, filter cloth can be used with the stone in these devices to further enhance sediment removal. Notably, the potential inconvenience of excessive ponding must be examined with these choices, especially the latter.

### Design Criteria

1. The drainage area shall be no greater than 1 acre.
2. The inlet protection device shall be constructed in a manner that will facilitate clean-out and disposal of trapped sediment and minimize interference with construction activities.
3. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.
4. Design criteria more specific to each particular inlet protection device will be found on Plates 3.07-1 through 3.07-8.
5. For the inlet protection devices which utilize stone as the chief ponding/filtering medium, a range of stone sizes is offered; VDOT #3, #357, or #5 Coarse Aggregate should be used. The designer/plan reviewer should attempt to get the greatest amount of filtering action possible (by using smaller-sized stone), while not creating significant ponding problems.
6. In all designs which utilize stone with a wire-mesh support as a filtering mechanism, the stone can be completely wrapped with the wire mesh to improve stability and provide easier cleaning.
7. Filter Fabric may be added to any of the devices which utilize "coarse aggregate" stone to significantly enhance sediment removal. The fabric, which must meet the physical requirements noted for "extra strength" found in Table 3.05-B, should be secured between the stone and the inlet (on wire-mesh if it is present). As a result of the significant increase in filter efficiency provided by the fabric, a larger range of stone sizes (VDOT #1, #2 or #3 Coarse Aggregate) may be utilized with such a configuration. The larger stone will help keep larger sediment masses from clogging the cloth. Notably, significant ponding may occur at the inlet if filter cloth is utilized in this manner.

### Construction Specifications

1. Silt Fence Drop Inlet Protection
  - a. Silt Fence shall conform to the construction specifications for "extra strength" found in Table 3.05-B and shall be cut from a continuous roll to avoid joints.
  - b. For stakes, use 2 x 4-inch wood (preferred) or equivalent metal with a minimum length of 3 feet.

- c. Space stakes evenly around the perimeter of the inlet a maximum of 3-feet apart, and securely drive them into the ground, approximately 18-inches deep (see Plate 3.07-1).
- d. To provide needed stability to the installation, frame with 2 x 4-inch wood strips around the crest of the overflow area at a maximum of 1½ feet above the drop inlet crest.
- e. Place the bottom 12 inches of the fabric in a trench (see Plate 3.07-1) and backfill the trench with 12 inches of compacted soil.
- f. Fasten fabric securely by staples or wire to the stakes and frame. Joints must be overlapped to the next stake.
- g. It may be necessary to build a temporary dike on the downslope side of the structure to prevent bypass flow.

2. Gravel and Wire Mesh Drop Inlet Sediment Filter

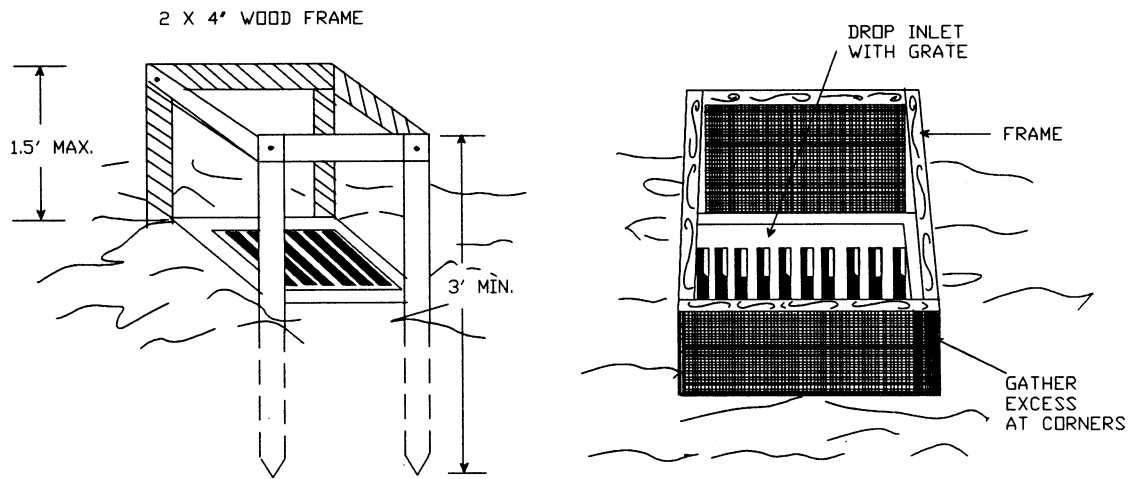
- a. Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Wire mesh with 1/2-inch openings shall be used. If more than one strip of mesh is necessary, the strips shall be overlapped.
- b. Coarse aggregate shall be placed over the wire mesh as indicated on Plate 3.07-2. The depth of stone shall be at least 12 inches over the entire inlet opening. The stone shall extend beyond the inlet opening at least 18 inches on all sides.
- c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and/or replaced.

Note: This filtering device has no overflow mechanism; therefore, ponding is likely especially if sediment is not removed regularly. This type of device must never be used where overflow may endanger an exposed fill slope. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, adjacent property, etc.

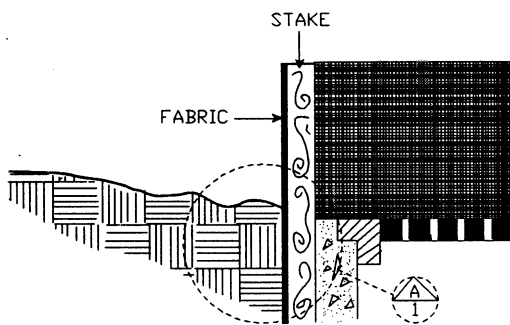
3. Block and Gravel Drop Inlet Sediment Filter

- a. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The height of the barrier can be varied, depending on design needs, by stacking combinations of 4-inch, 8-inch and 12-inch wide blocks. The barrier of blocks shall be at least 12-inches high and no greater than 24-inches high.

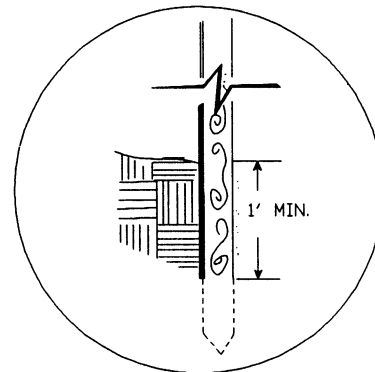
## SILT FENCE DROP INLET PROTECTION



PERSPECTIVE VIEWS



ELEVATION OF STAKE AND  
FABRIC ORIENTATION



DETAIL A

### SPECIFIC APPLICATION

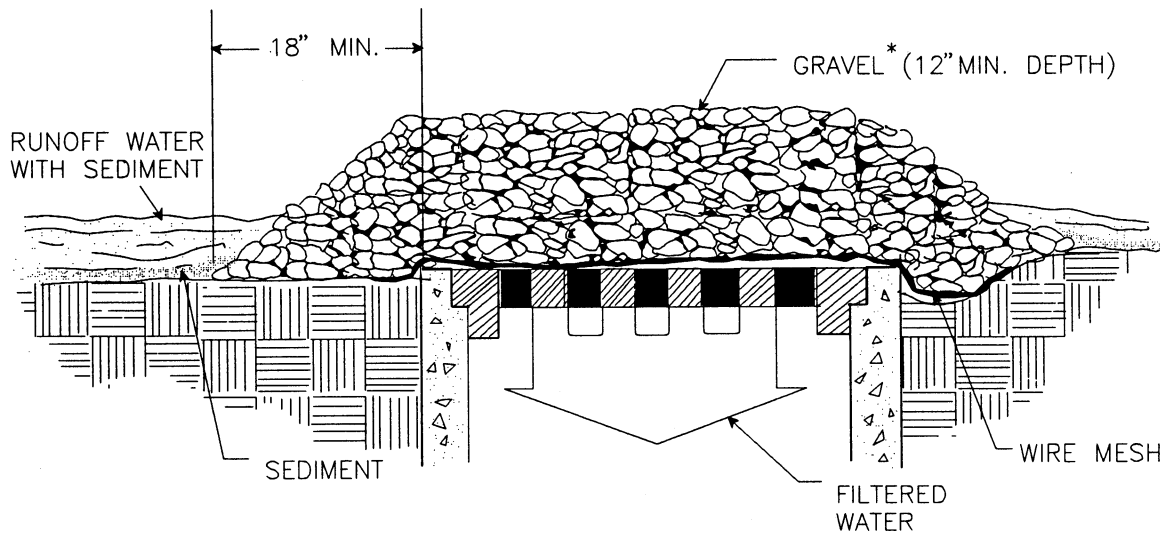
THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE THE INLET DRAINS A RELATIVELY FLAT AREA (SLOPE NO GREATER THAN 5%) WHERE THE INLET SHEET OR OVERLAND FLOWS (NOT EXCEEDING 1 C.F.S.) ARE TYPICAL. THE METHOD SHALL NOT APPLY TO INLETS RECEIVING CONCENTRATED FLOWS, SUCH AS IN STREET OR HIGHWAY MEDIANS.

Source: N.C. Erosion and Sediment Control  
Planning and Design Manual, 1988

Plate 3.07-1



## *GRAVEL AND WIRE MESH DROP INLET SEDIMENT FILTER*



### SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY CONCENTRATED FLOWS ARE EXPECTED, BUT NOT WHERE PONDING AROUND THE STRUCTURE MIGHT CAUSE EXCESSIVE INCONVENIENCE OR DAMAGE TO ADJACENT STRUCTURES AND UNPROTECTED AREAS.

\* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE.

- b. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 1/2-inch openings shall be used.
- c. Stone shall be piled against the wire to the top of the block barrier, as shown in Plate 3.07-3.
- d. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced.

4. Excavated Drop Inlet Sediment Trap

- a. The excavated trap shall be sized to provide a minimum storage capacity calculated at the rate of 134 cubic yards per acre of drainage area. A trap shall be no less than 1-foot nor more than 2-feet deep measured from the top of the inlet structure. Side slopes shall not be steeper than 2:1 (see Plate 3.07-4).
- b. The slope of the basin may vary to fit the drainage area and terrain. Observations must be made to check trap efficiency and modifications shall be made as necessary to ensure satisfactory trapping of sediment. Where an inlet is located so as to receive concentrated flows, such as in a highway median, it is recommended that the basin have a rectangular shape in a 2:1 (length/width) ratio, with the length oriented in the direction of the flow.
- c. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in a manner such that it will not erode.

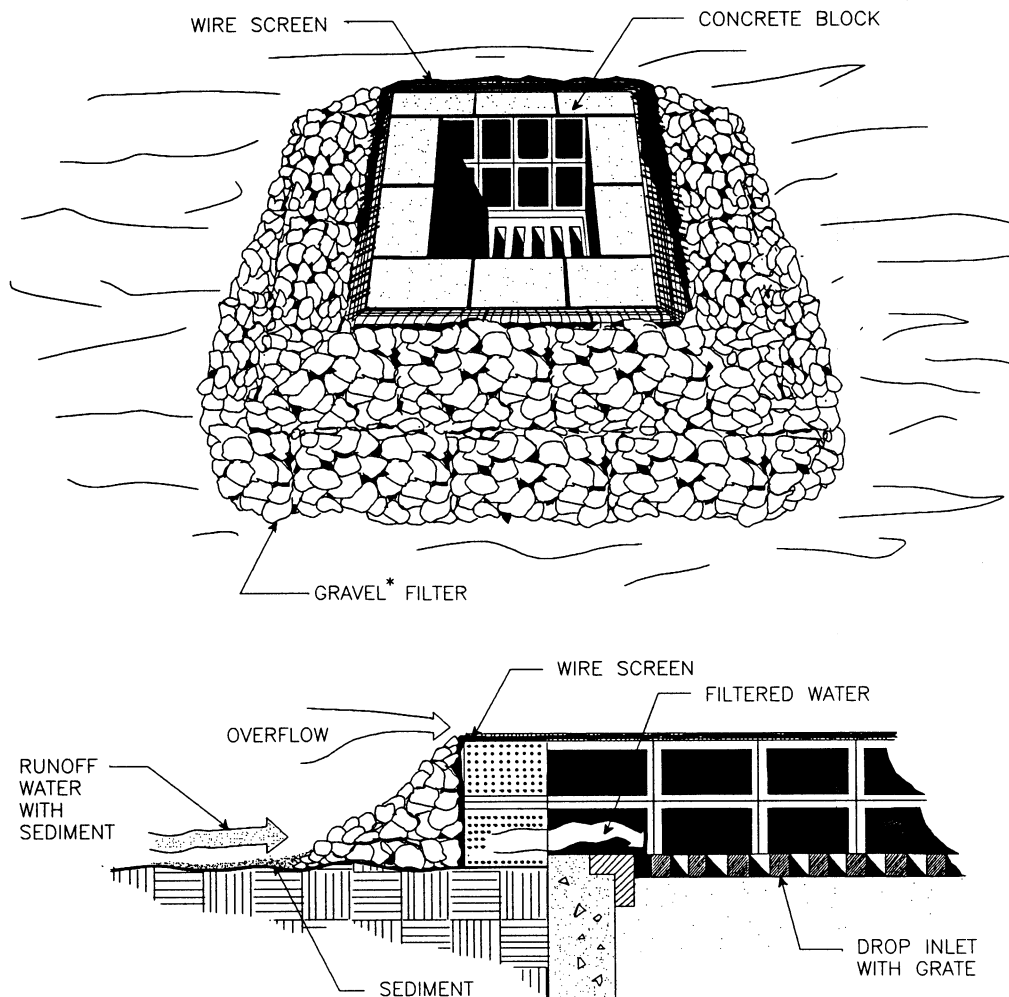
5. Sod Drop Inlet Sediment Filter

- a. Soil shall be prepared and sod installed according to the specifications in Std. & Spec. 3.33, SODDING.
- b. Sod shall be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure, as depicted in Plate 3.07-5.

6. Gravel Curb Inlet Sediment Filter

- a. Wire mesh with 1/2-inch openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the inlet cover and at least 12 inches of wire extends across the concrete gutter from the inlet opening, as depicted in Plate 3.07-6.

## *BLOCK AND GRAVEL DROP INLET SEDIMENT FILTER*

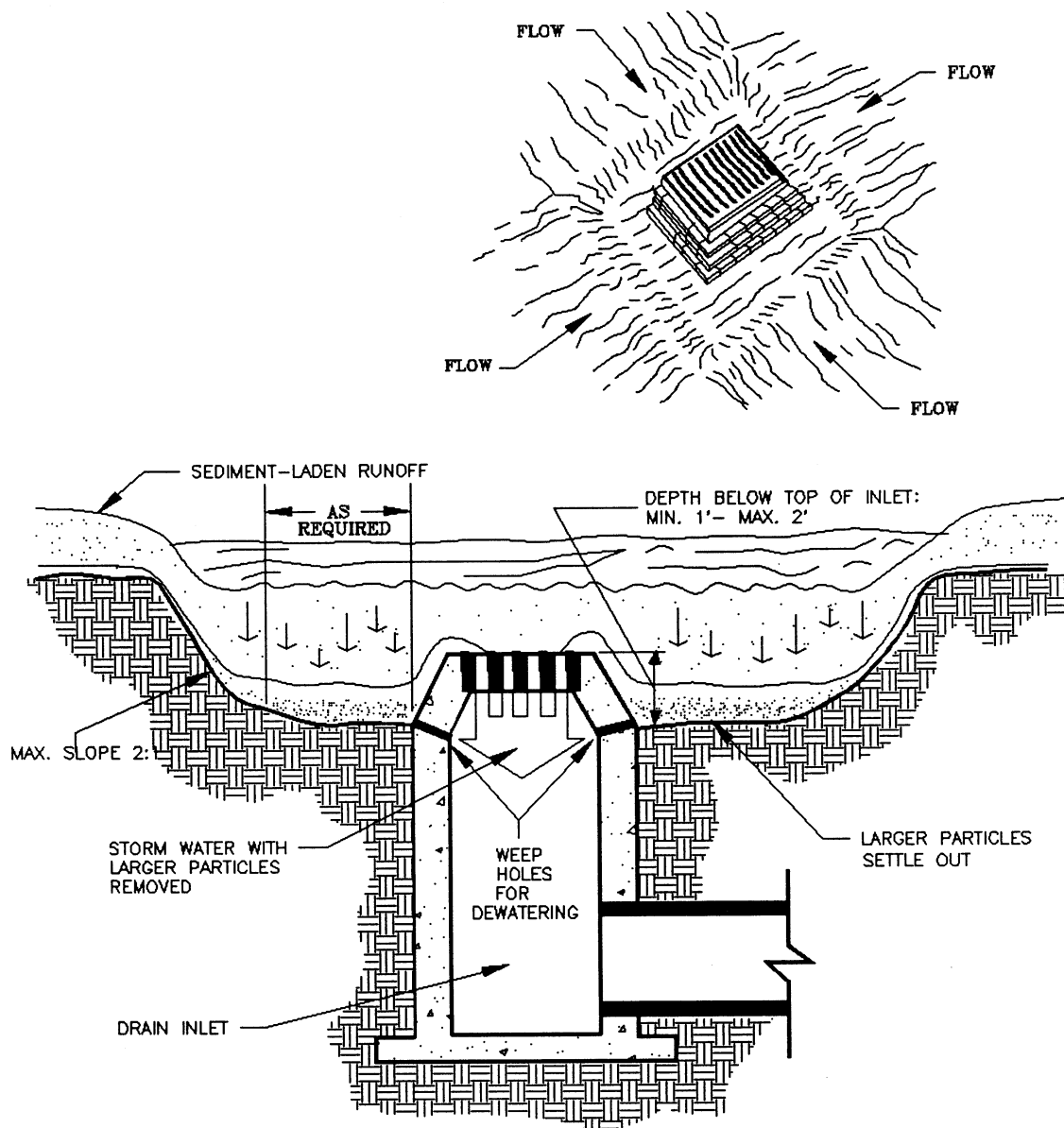


### SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY FLOWS ARE EXPECTED AND WHERE AN OVERFLOW CAPACITY IS NECESSARY TO PREVENT EXCESSIVE PONDING AROUND THE STRUCTURE.

\* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE.

## EXCAVATED DROP INLET SEDIMENT TRAP



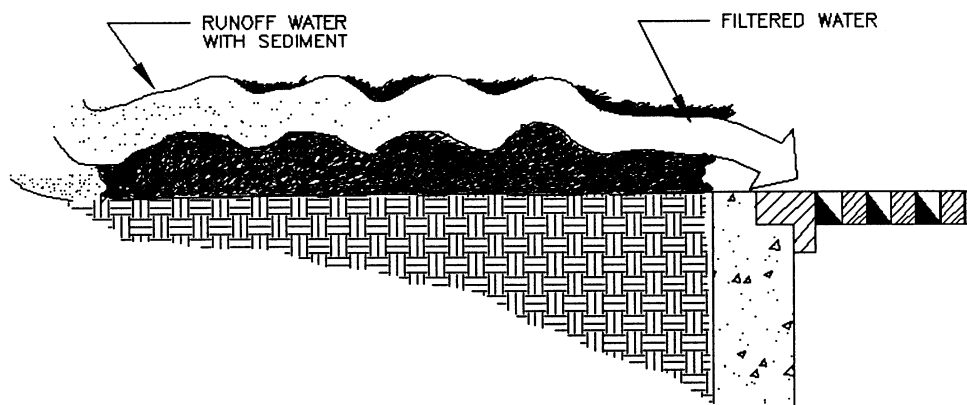
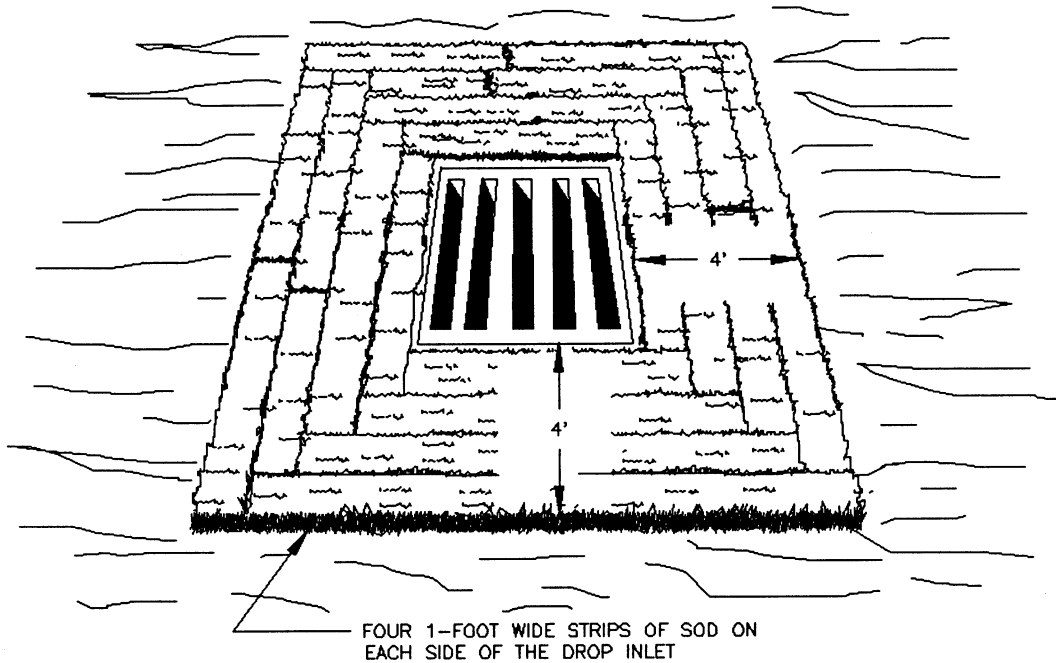
### SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY FLOWS ARE EXPECTED AND WHERE AN OVERFLOW CAPABILITY AND EASE OF MAINTENANCE ARE DESIRABLE.

Source: Michigan Soil Erosion and Sediment Control Guidebook, 1975, and USDA-SCS

Plate 3.07-4

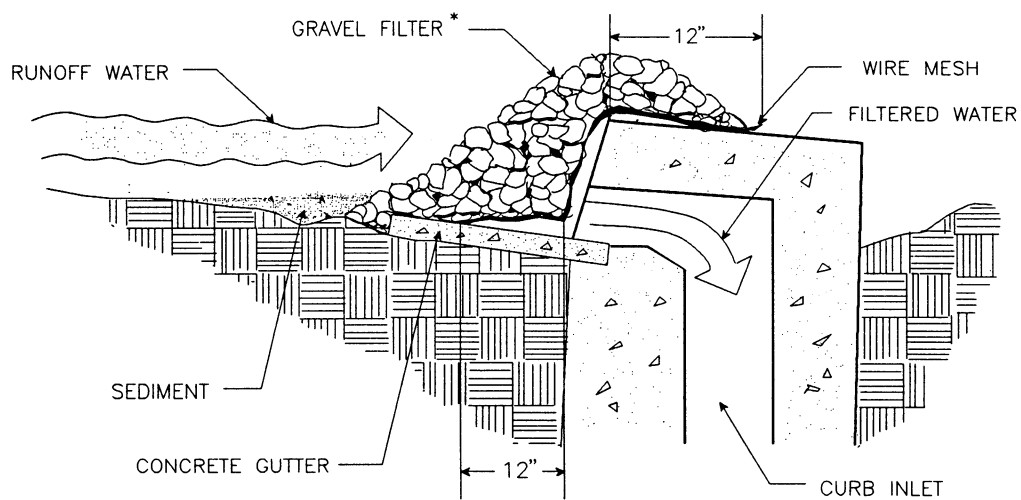
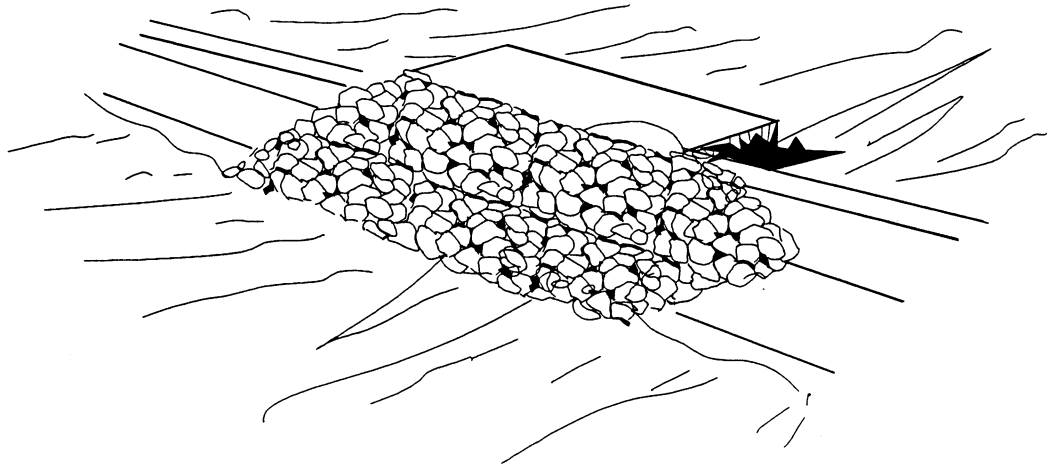
## *SOD DROP INLET SEDIMENT FILTER*



### SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE ONLY AT THE TIME OF PERMANENT SEEDING, TO PROTECT THE INLET FROM SEDIMENT AND MULCH MATERIAL UNTIL PERMANENT VEGETATION HAS BECOME ESTABLISHED.

## *GRAVEL CURB INLET SEDIMENT FILTER*



### SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE AT CURB INLETS WHERE PONDING IN FRONT OF THE STRUCTURE IS NOT LIKELY TO CAUSE INCONVENIENCE OR DAMAGE TO ADJACENT STRUCTURES AND UNPROTECTED AREAS.

\* GRAVEL SHALL BE VDOT #3, #357 OR 5 COARSE AGGREGATE.

- b. Stone shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely.
- c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the block, cleaned and replaced.

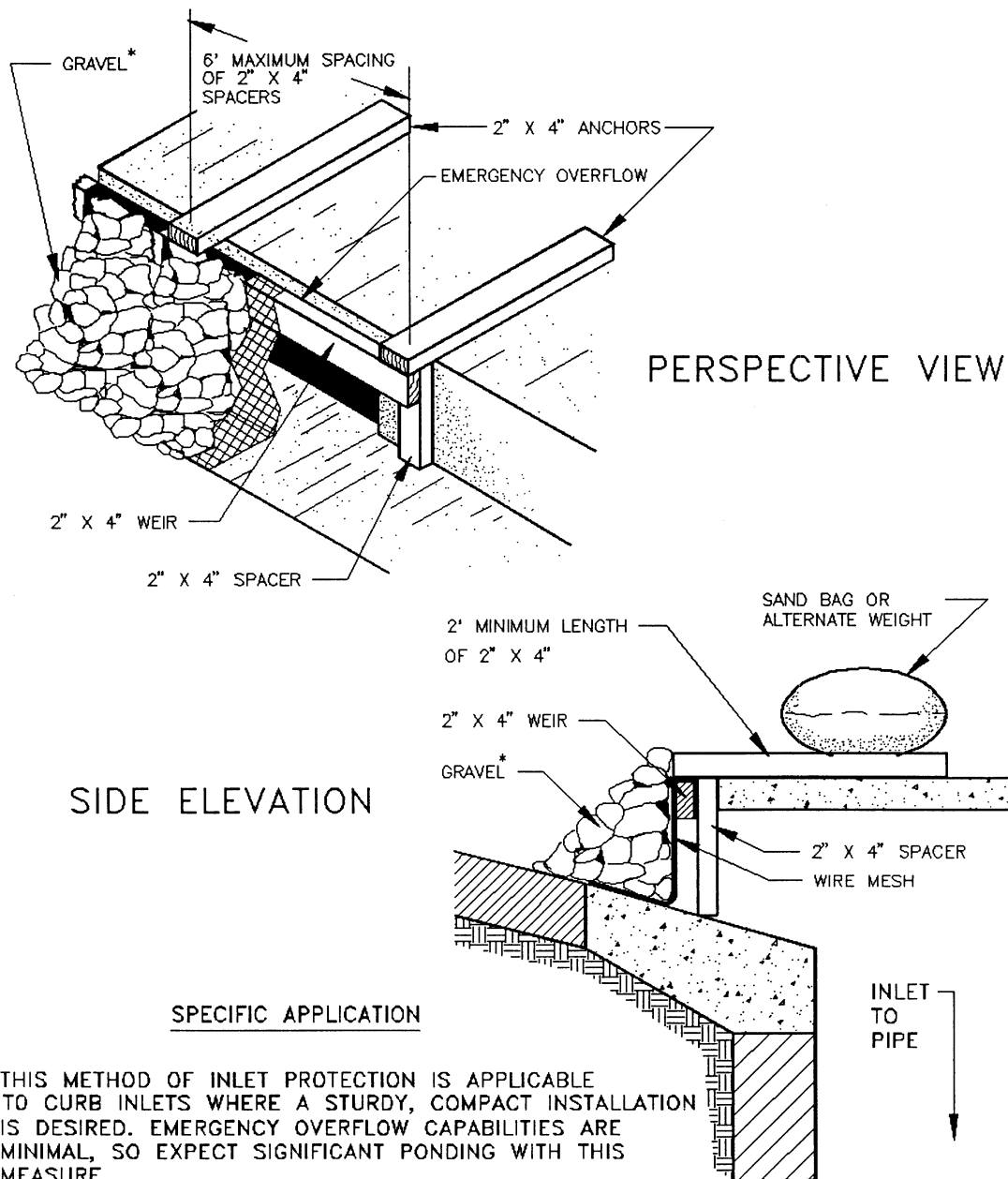
7. Curb Inlet Protection with 2-inch x 4-inch Wooden Weir

- a. Attach a continuous piece of wire mesh (30-inch minimum width x inlet throat length plus 4 feet) to the 2-inch x 4-inch wooden weir (with a total length of throat length plus 2 feet) as shown in Plate 3.07-7. Wood should be "construction grade" lumber.
- b. Place a piece of approved "extra-strength" filter cloth of the same dimensions as the wire mesh over the wire mesh and securely attach to the 2-inch x 4-inch weir.
- c. Securely nail the 2-inch x 4-inch weir to the 9-inch long vertical spacers which are to be located between the weir and inlet face at a maximum 6-foot spacing.
- d. Place the assembly against the inlet throat and nail 2-foot (minimum) lengths of 2-inch x 4-inch board to the top of the weir at spacer locations. These 2-inch x 4-inch anchors shall extend across the inlet tops and be held in place by sandbags or alternate weight.
- e. The assembly shall be placed so that the end spacers are a minimum 1 foot beyond both ends of the throat opening.
- f. Form the wire mesh and filter cloth to the concrete gutter and against the face of curb on both sides of the inlet. Place coarse aggregate over the wire mesh and filter fabric in such a manner as to prevent water from entering the inlet under or around the filter cloth.
- g. This type of protection must be inspected frequently and the filter cloth and stone replaced when clogged with sediment.
- h. Assure that storm flow does not bypass inlet by installing temporary earth or asphalt dikes directing flow into inlet.

8. Block and Gravel Curb Inlet Sediment Filter

- a. Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening.

# *CURB INLET PROTECTION WITH 2-INCH X 4-INCH WOODEN WEIR*



\* GRAVEL SHALL BE VDOT COARSE AGGREGATE  
#3, #357 OR #5

Source: 1983 Maryland Standards and Specifications for  
Soil Erosion and Sediment Control, and USDA-SCS

Plate 3.07-7

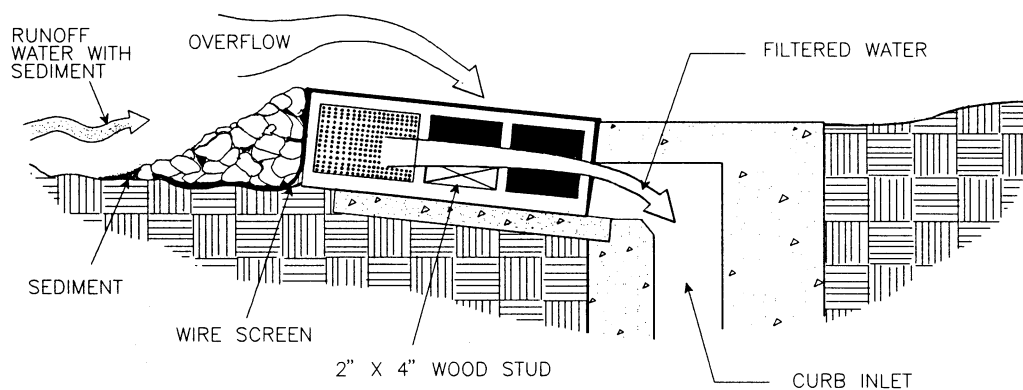
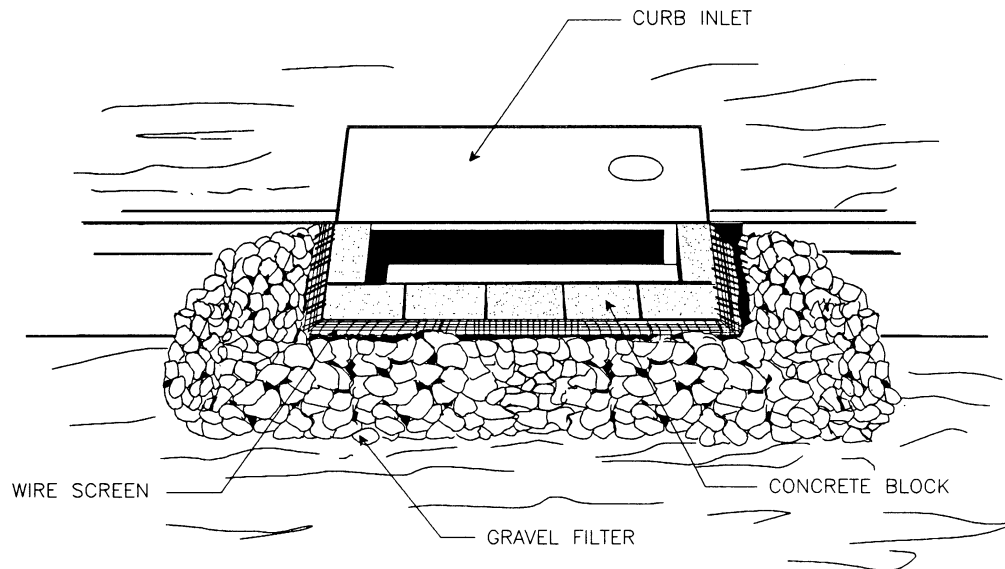


- b. A 2-inch x 4-inch stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.
- c. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks as depicted in Plate 3.07-8.
- d. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 1/2-inch openings shall be used.
- e. Coarse aggregate shall be piled against the wire to the top of the barrier as shown in Plate 3.07-8.
- f. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and/or replaced.

#### Maintenance

- 1. The structure shall be inspected after each rain and repairs made as needed.
- 2. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
- 3. Structures shall be removed and the area stabilized when the remaining drainage area has been properly stabilized.

## *BLOCK & GRAVEL CURB INLET SEDIMENT FILTER*

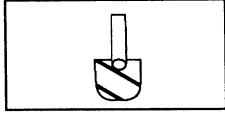


### SPECIAL APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE AT CURB INLETS WHERE AN OVERFLOW CAPABILITY IS NECESSARY TO PREVENT EXCESSIVE PONDING IN FRONT OF THE STRUCTURE.

\* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE

## STD &amp; SPEC 3.08



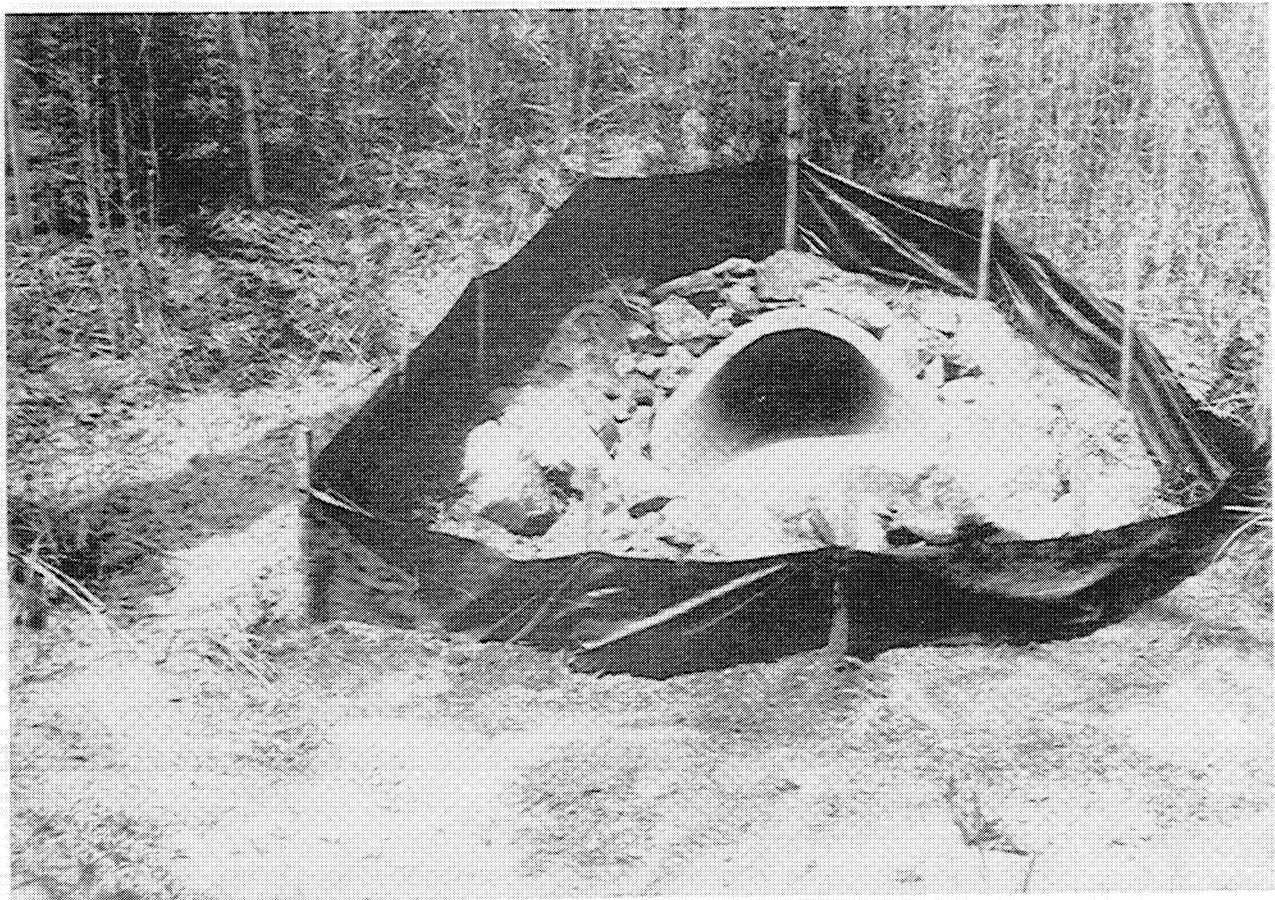
## CULVERT INLET PROTECTION

Definition

A sediment filter located at the inlet to storm sewer culverts.

Purposes

1. To prevent sediment from entering, accumulating in and being transferred by a culvert and associated drainage system prior to permanent stabilization of a disturbed project area.
2. To provide erosion control at culvert inlets during the phase of a project where elevation and drainage patterns change, causing original control measures to be ineffective or in need of removal.



### Conditions Where Practice Applies

Where culvert and associated drainage system is to be made operational prior to permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions (see Plates 3.08-1 and 3.08-2).

### Planning Considerations

When construction on a project reaches a stage where culverts and other storm sewer appurtenances are installed and many areas are brought to a desired grade, the erosion control measures used in the early stages normally need to be modified or may need to be removed altogether. At that time, there is a need to provide protection at the points where runoff will leave the area via culverts and drop or curb inlets.

Similar to drop and curb inlets, culverts which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the pipe or pipe system itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the culvert by using one of the methods noted in this section.

### General Guidelines (All Types)

1. The inlet protection device shall be constructed in a manner that will facilitate clean-out and disposal of trapped sediment and minimize interference with construction activities.
2. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.
3. Design criteria more specific to each particular inlet protection device will be found in Plates 3.08-1 through 3.08-2.

### Design Criteria

1. Silt Fence Culvert Inlet Protection
  - a. No formal design is required.
  - b. Silt fence culvert inlet protection has an expected maximum usable life of three months.
  - c. The maximum area draining to this practice shall not exceed one acre.

## 2. Culvert Inlet Sediment Trap

- a. Runoff storage requirements shall be in accordance with information outlined under Std. & Spec. 3.13, TEMPORARY SEDIMENT TRAP.
- b. Culvert inlet sediment traps have a maximum expected useful life of 18 months.
- c. The maximum area draining to this practice shall not exceed 3 acres.

### Construction Specifications

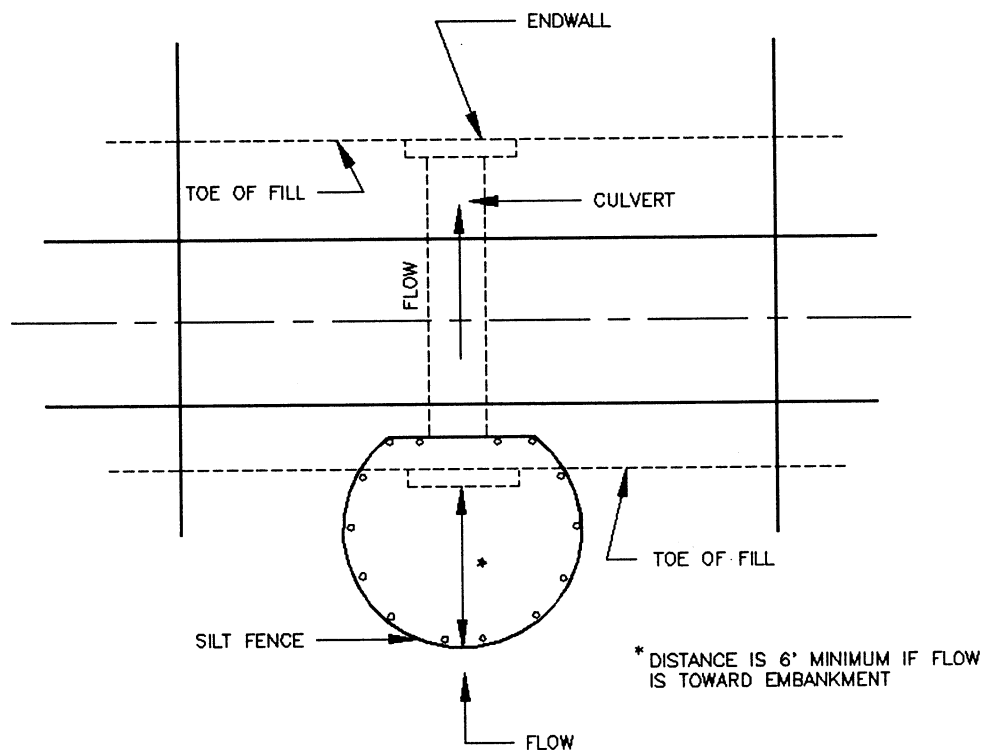
#### 1. Silt Fence Culvert Inlet Protection

- a. The height of the silt fence (in front of the culvert opening) shall be a minimum of 16 inches and shall not exceed 34 inches.
- b. Extra strength filter fabric with a maximum spacing of stakes of 3 feet shall be used to construct the measure.
- c. The placement of silt fence should be approximately 6 feet from the culvert in the direction of incoming flow, creating a "horseshoe" shape as shown in Plate 3.08-1.
- d. If silt fence cannot be installed properly or the flow and/or velocity of flow to the culvert protection is excessive and may breach the structure, the stone combination noted in Plate 3.08-1 should be utilized.

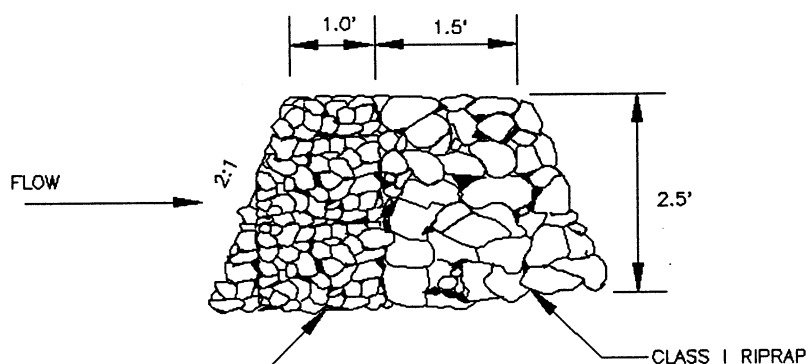
#### 2. Culvert Inlet Sediment Trap

- a. Geometry of the design will be a "horseshoe" shape around the culvert inlet (see Plate 3.08-2).
- b. The toe of riprap (composing the sediment filter dam) shall be no closer than 24" from the culvert opening in order to provide an acceptable emergency outlet for flows from larger storm events.
- c. All other "Construction Specifications" found within Std. & Spec. 3.13, TEMPORARY SEDIMENT TRAP, also apply to this practice.
- e. The proper installation of the culvert inlet sediment trap is a viable substitute for the installation of the TEMPORARY SEDIMENT TRAP.

# SILT FENCE CULVERT INLET PROTECTION



## OPTIONAL STONE COMBINATION\*\*

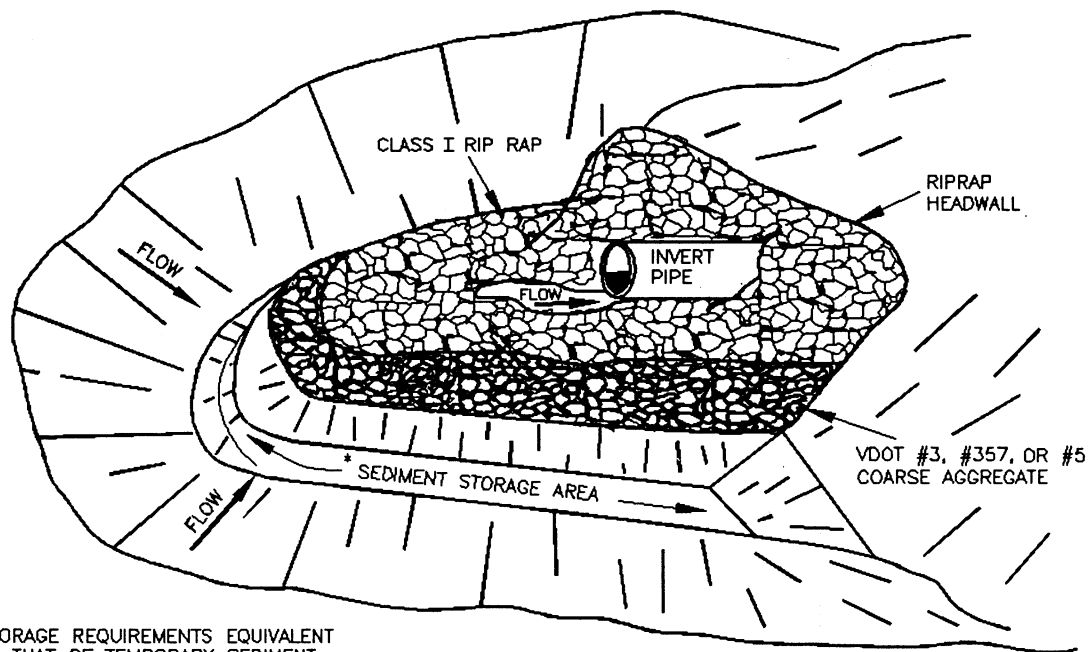


VDOT #3, #357 OR #5 COARSE AGGREGATE  
TO REPLACE SILT FENCE IN " HORSESHOE " WHEN  
HIGH VELOCITY OF FLOW IS EXPECTED

**Source:** Adapted from VDOT Standard  
Sheets and Va. DSWC

Plate 3.08-1

# CULVERT INLET SEDIMENT TRAP

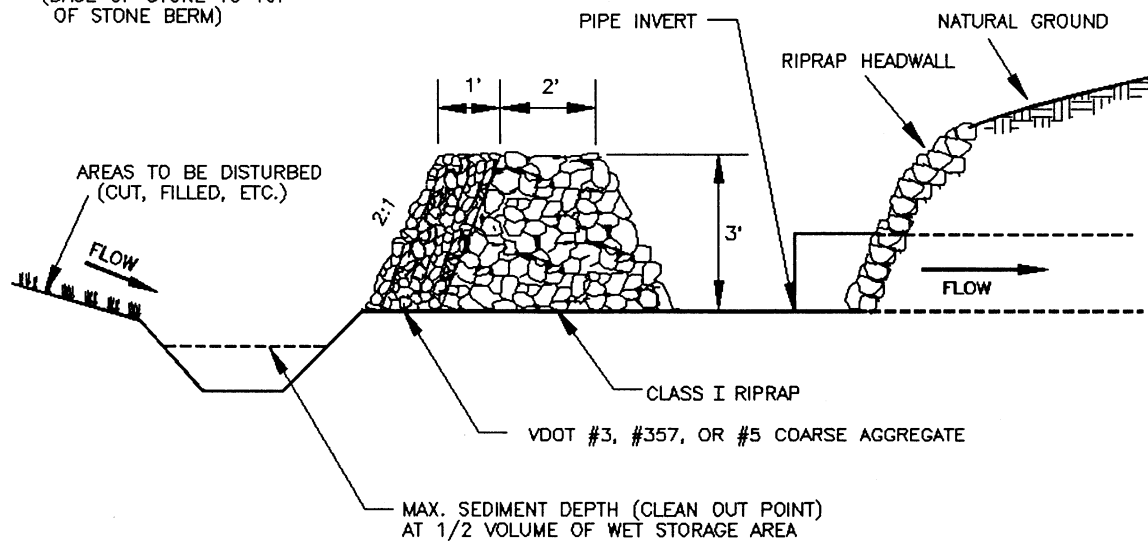


\*STORAGE REQUIREMENTS EQUIVALENT  
TO THAT OF TEMPORARY SEDIMENT  
TRAP, STD. & SPEC. 3.13

67 C.Y./ACRE WET STORAGE  
(BELOW BASE OF STONE)

67 C.Y./ACRE DRY STORAGE  
(BASE OF STONE TO TOP  
OF STONE BERM)

## PERSPECTIVE VIEW



## ELEVATION

Source: North Carolina Sediment Control Commission

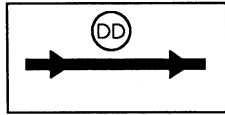
Plate 3.08-2

Maintenance

1. The structure shall be inspected after each rain and repairs made as needed.
2. Aggregate shall be replaced or cleaned when inspection reveals that clogged voids are causing ponding problems which interfere with on-site construction.
3. Sediment shall be removed and the impoundment restored to its original dimensions when sediment has accumulated to one-half the design depth. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.
4. Temporary structures shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.



## STD &amp; SPEC 3.09



## TEMPORARY DIVERSION DIKE

Definition

A temporary ridge of compacted soil constructed at the top or base of a sloping disturbed area.

Purposes

1. To divert storm runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet.
2. To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a sediment trap or sediment basin.

Conditions Where Practice Applies

Wherever stormwater runoff must be temporarily diverted to protect disturbed areas and slopes or retain sediment on site during construction. These structures generally have a life expectancy of 18 months or less, which can be prolonged with proper maintenance.



### Planning Considerations

A temporary diversion dike is intended to divert overland sheet flow to a stabilized outlet or a sediment-trapping facility during establishment of permanent stabilization on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

As per M.S. #5, it is very important that a temporary diversion dike be stabilized immediately following installation with temporary or permanent vegetation to prevent erosion of the dike itself. The gradient of the channel behind the dike is also an important consideration. The dike must have a positive grade to assure drainage, but if the gradient is too great, precautions must be taken to prevent erosion due to high-velocity channel flow behind the dike. The cross-section of the channel which runs behind the dike should be of a parabolic or trapezoidal shape to help inhibit a high velocity of flow which could arise in a vee ditch.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the dike with vegetation. Diversion dikes are preferable to silt fence because they are more durable, less expensive, and require much less maintenance when constructed properly. Along with a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13), they become a logical choice for a control measure once the control limits of the silt fence or straw bale barrier have been exceeded.

Temporary diversion dikes are often used as a perimeter control in association with a sediment trap or a sediment basin, or a series of sediment-trapping facilities, on moderate to large construction sites. If installed properly and in the first phase of grading, maintenance costs are very low. Often, cleaning of sediment-trapping facilities is the only associated maintenance requirement.

As specified herein, this practice is intended to be temporary. However, with more stringent design criteria, it can be made permanent in accordance with DIVERSIONS (Std. & Spec. 3.12).

### Design Criteria

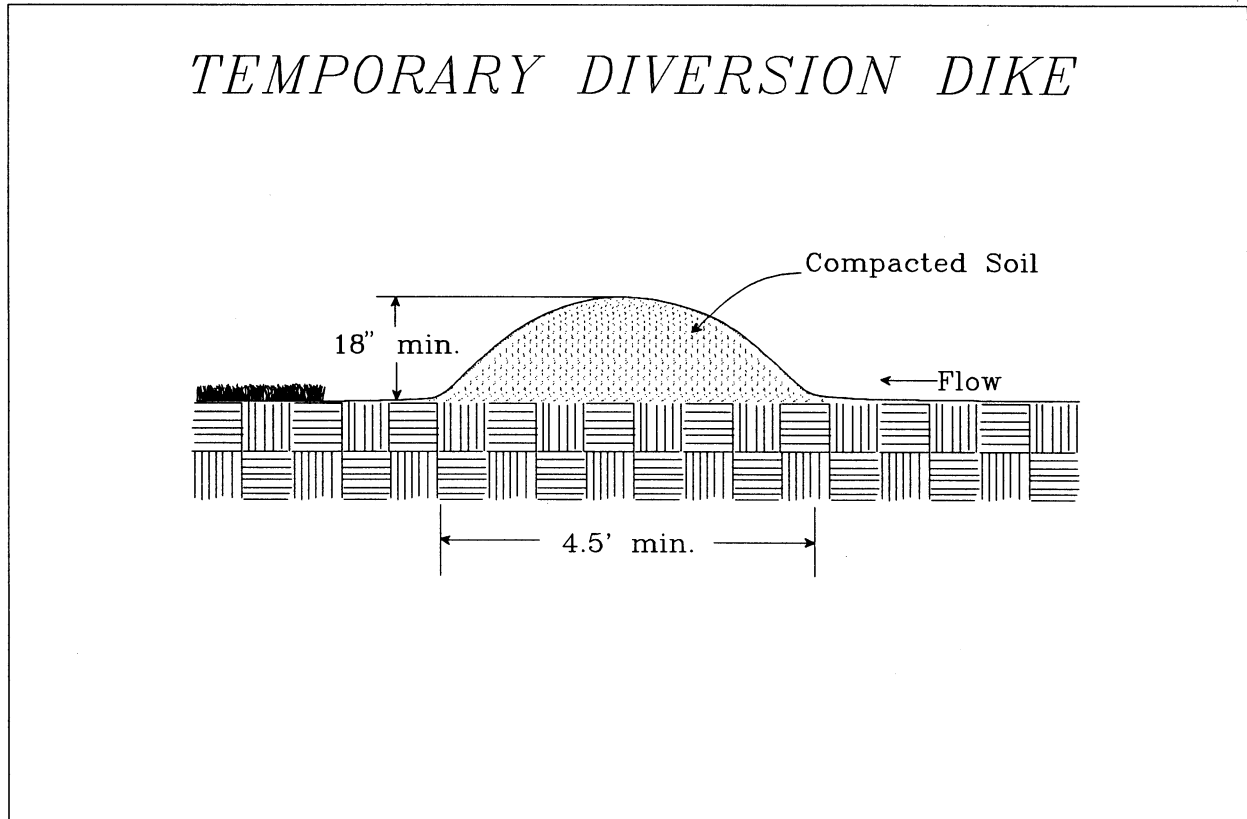
No formal design is required. The following criteria shall be met:

#### Drainage Area

The maximum allowable drainage area is 5 acres.

Height

The minimum allowable height measured from the upslope side of the dike is 18 inches (see Plate 3.09-1).



Source: Va. DSWC

Plate 3.09-1

Side Slopes

1½:1 or flatter, along with a minimum base width of 4.5 feet (see Plate 3.09-1).

Grade

The channel behind the dike shall have a positive grade to a stabilized outlet. If the channel slope is less than or equal to 2%, no stabilization is required. If the slope is greater than 2%, the channel shall be stabilized in accordance with Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL.

Outlet

1. The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.

2. Sediment-laden runoff must be diverted and released through a sediment-trapping facility such as a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) or TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14).

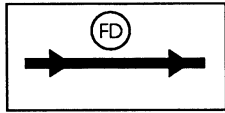
#### Construction Specifications

1. Temporary diversion dikes must be installed as a first step in the land-disturbing activity and must be functional prior to upslope land disturbance.
2. The dike should be adequately compacted to prevent failure.
3. Temporary or permanent seeding and mulch shall be applied to the dike immediately following its construction.
4. The dike should be located to minimize damages by construction operations and traffic.

#### Maintenance

The measure shall be inspected after every storm and repairs made to the dike, flow channel, outlet or sediment trapping facility, as necessary. Once every two weeks, whether a storm event has occurred or not, the measure shall be inspected and repairs made if needed. Damages caused by construction traffic or other activity must be repaired before the end of each working day.

## STD &amp; SPEC 3.10



## TEMPORARY FILL DIVERSION

Definition

A channel with a supporting ridge of soil on the lower side, constructed along the top of an active earth fill.

Purpose

To divert storm runoff away from the unprotected slope of the fill to a stabilized outlet or sediment-trapping facility.

Conditions Where Practice Applies

Where the drainage area at the top of an active earth fill slopes toward the exposed slope and where continuous fill operations make the use of a DIVERSION (Std. & Spec. 3.12) unfeasible. This temporary structure should remain in place for less than one week.



### Planning Considerations

One important principle of erosion and sediment control is to keep stormwater runoff away from exposed slopes. This is often accomplished by installing a dike, diversion, temporary slope drain or paved ditch at the top of a slope to carry the runoff away from the slope to a stabilized outlet. In general, these measures are installed after the final grade has been reached. On cuts, the measures may be installed at the beginning since the work proceeds from the top to the bottom of the slope, and the measures have little chance of being covered or damaged. On fills, the work proceeds from the bottom to the top and the elevation changes daily. It is therefore not feasible to construct a compacted dike or permanent diversion which may be covered by the next day's activity.

The temporary fill diversion is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. This practice can be constructed by the use of a motor grader or a small dozer. To shape the diversion, the piece of machinery used may run near the top edge of the fill with its blade tilted to form the channel as depicted in Plate 3.10-1. This work would be done at the end of the working day and provide a channel with a berm to protect the slope. Wherever possible, the temporary diversion should be sloped to direct water to a stabilized outlet. If the runoff is diverted over the fill itself, the practice may cause erosion by concentrating water at a single point.

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope protection measures and slope stabilization measures installed as soon after completion as possible. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing and stabilizing the fill area. The longer the time period for construction and stabilization extends, the more prone the fill operation is to be damaged by erosion. Repairing the damages adds additional time and expense to the project.

### Design Criteria

No formal design is required. The following criteria shall be met:

#### Drainage Area

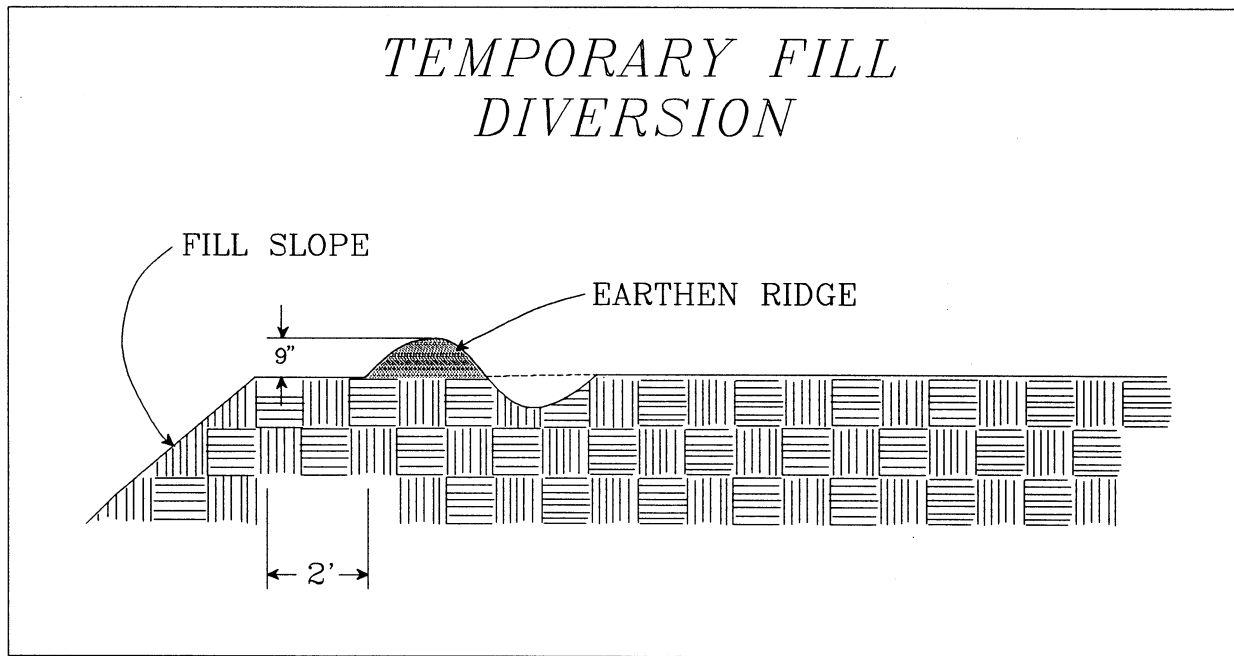
The maximum allowable drainage area is 5 acres.

#### Height

The minimum height of the supporting ridge shall be 9 inches (see Plate 3.10-1).

#### Grade

The channel shall have a positive grade to a stabilized outlet.



Source: Va. DSWC

Plate 3.10-1

### Outlet

The diverted runoff should be released through a stabilized outlet, slope drain or sediment trapping measure.

### Construction Specifications

1. The diversion shall be constructed at the top of the fill at the end of each work day as needed.
2. The diversion shall be located at least 2 feet inside the top edge of the fill (see Plate 3.10-1).
3. The supporting ridge shall be constructed with a uniform height along its entire length. Without uniform height, the fill diversion may be susceptible to breaching.

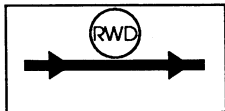
### Maintenance

Since the practice is temporary and under most situations will be covered the next work day, the maintenance required should be low. If the practice is to remain in use for more than

one day, an inspection will be made at the end of each work day and repairs made to the measure if needed. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the diversion.



## STD &amp; SPEC 3.11

TEMPORARY RIGHT-OF-WAY  
DIVERSIONDefinition

A ridge of compacted soil or loose rock or gravel constructed across disturbed rights-of-way and similar sloping areas.

Purpose

To shorten the flow length within a sloping right-of-way, thereby reducing the erosion potential by diverting storm runoff to a stabilized outlet.

Conditions Where Practice Applies

Generally, earthen diversions are applicable where there will be little or no construction traffic within the right-of-way. Gravel structures are more applicable to roads and other rights-of-way which accommodate vehicular traffic.



### Planning Considerations

Construction of utility lines and roads often requires the clearing of long strips of right-of-way over sloping terrain. The volume and velocity of stormwater runoff tend to increase in these cleared strips and the potential for erosion is much greater since the vegetative cover is diminished or removed. To compensate for the loss of vegetation, it is usually a good practice to break up the flow length within the cleared strip so that runoff does not have a chance to concentrate and cause erosion. At proper intervals, temporary right-of-way diversions can significantly reduce the amount of erosion which will occur until the area is permanently stabilized. Since many right-of-ways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetative buffer strip (if it provides a minimum flow length of 75 feet).

### Design Criteria

No formal design is required. The following criteria shall be met:

#### Height

The minimum allowable height of the diversion is 18 inches (see Plate 3.11-1).

#### Side Slopes

Side slopes should be 2:1 or flatter to allow the passage of construction traffic, along with a minimum base width of 6 feet (see Plate 3.11-1).

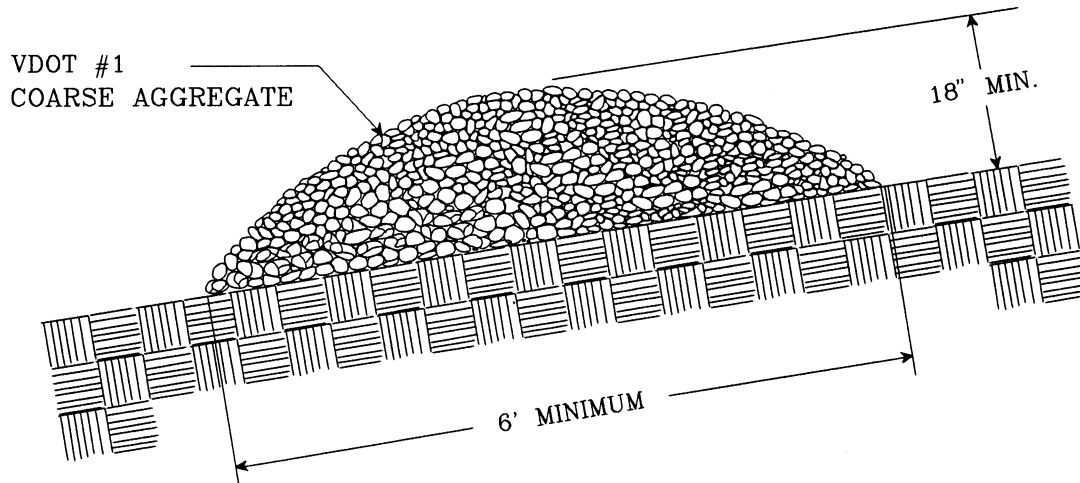
#### Width

The measure should be constructed completely across the disturbed portion of the right-of-way.

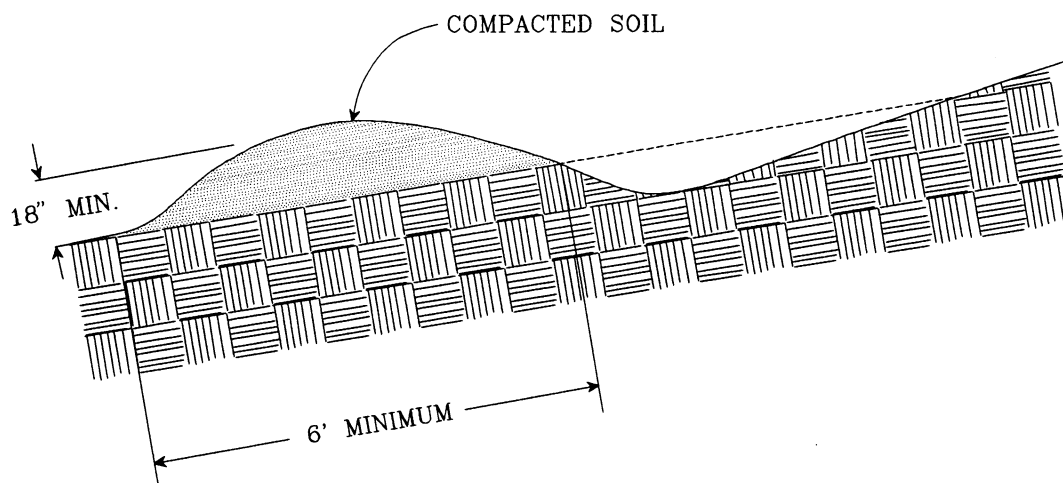
#### Spacing

Table 3.11-A will be used to determine the spacing of right-of-way diversions.

## TEMPORARY RIGHT-OF-WAY DIVERSIONS



### TYPICAL GRAVEL STRUCTURE



### TYPICAL EARTHEN STRUCTURE

**TABLE 3.11-A**  
**SPACING OF RIGHT-OF-WAY DIVERSIONS**

<u>% Slope</u>	<u>Spacing (ft.)</u>
Less than 7%	100
Between 7% and 25%	75
Between 25% and 40%	50
Greater than 40%	25

Source: Va. DSWC

### Grade

Positive drainage (with less than 2% slope) should be provided to a stabilized outlet, sediment-trapping facility, or a vegetative buffer strip of adequate size.

### Outlet

Interceptor dikes must have an outlet which is not subject to erosion.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet. Concentrated flows should spread over the widest possible area after release. Flows with high sediment concentrations should pass through an appropriate sediment-trapping measure.

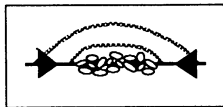
### Construction Specifications

1. The diversion shall be installed as soon as the right-of-way has been cleared and/or graded.
2. All earthen diversions shall be machine- or hand-compacted in 8-inch lifts.
3. The outlet of the diversion shall be located on an undisturbed and stabilized area when at all possible. The field location should be adjusted as needed to utilize a stabilized outlet.
4. Earthen diversions which will not be subject to construction traffic should be stabilized in accordance with TEMPORARY SEEDING (Std. & Spec. 3.31).

### Maintenance

The practice shall be inspected after every rainfall and repairs made if necessary. At least once every two weeks, whether a storm has occurred or not, the measure shall be inspected and repairs made if needed. Right-of-way diversions, which are subject to damage by vehicular traffic, should be reshaped at the end of each working day.

## STD &amp; SPEC 3.13



## TEMPORARY SEDIMENT TRAP

Definition

A temporary ponding area formed by constructing an earthen embankment with a stone outlet.

Purpose

To detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies

1. Below disturbed areas where the total contributing drainage area is less than 3 acres.



2. Where the sediment trap will be used no longer than 18 months (the maximum useful life is 18 months).
3. The sediment trap may be constructed either independently or in conjunction with a TEMPORARY DIVERSION DIKE (Std. & Spec. 3.09).

### Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is 3 acres or greater, refer to SEDIMENT BASIN (Std. & Spec. 3.14).

Sediment traps, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

Recent studies have been conducted on the performance of sediment traps (and basins) which were constructed using the design criteria found in previous editions of this handbook. The studies indicate that the control measures only achieved a 46% removal of sediment which flowed into them during storm events which caused measurable outflow. To achieve a more acceptable removal rate (60%), it was necessary to revise the design of these measures in this handbook. The total initial storage volume for both the sediment trap and the TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14) has been doubled. There are both a "wet" storage volume and a drawdown or "dry" storage volume which help to enhance sediment fall-out and prevent excessive sediment losses during large storm events which occur during the advanced stages of land disturbance (28).

In most cases excavation will be required to attain the necessary storage volume. Also, sediment must be periodically removed from the trap to maintain the required volume. Plans should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

As noted previously in this handbook, there are numerous other acceptable ways to design many of the erosion control practices within. This is certainly true in the case of the sediment trap. However, variations in its design should be considered judiciously by plan reviewers to ensure that the minimum storage requirements and structural integrity noted in this specification are maintained.

### Design Criteria

#### Trap Capacity

The sediment trap must have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half shall be in the form of a drawdown

or dry storage which will provide extended settling time during less frequent, larger storm events. The volume of the wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure. The volume of the dry storage shall be measured from the base of the stone outlet to the crest of the stone outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85 \times A_1 \times D_1$$

where,

$V_1$  = the wet storage volume in cubic feet

$A_1$  = the surface area of the flooded area at the base of the stone outlet in square feet

$D_1$  = the maximum depth in feet, measured from the low point in the trap to the base of the stone outlet

The dry storage volume may be approximated as follows:

$$V_2 = \frac{A_1 + A_2}{2} \times D_2$$

where,

$V_2$  = the dry storage volume in cubic feet

$A_1$  = the surface area of the flooded area at the base of the stone outlet in square feet

$A_2$  = the surface area of the flooded area at the crest of the stone outlet (overflow mechanism), in square feet

$D_2$  = the depth in feet, measured from the base of the stone outlet to the crest of the stone outlet

The designer should seek to provide a storage area which has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).



Note: Conversion between cubic feet and cubic yards is as follows:

$$\text{number of cubic feet} \times 0.037 = \text{number of cubic yards}$$

### Excavation

Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within the wet storage area should be 4 feet to facilitate clean-out and for site safety considerations.

### Outlet

The outlet for the sediment trap shall consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention as well as outlet stability. The smaller stone shall be VDOT #3, #357, or #5 Coarse Aggregate (smaller stone sizes will enhance filter efficiency) and riprap shall be "Class I." Filter cloth which meets the physical requirements noted in Std. & Spec. 3.19, RIPRAP shall be placed at the stone-soil interface to act as a "separator." The minimum length of the outlet shall be 6 feet times the number of acres comprising the total area draining to the trap. The crest of the stone outlet must be at least 1.0 foot below the top of the embankment to ensure that the flow will travel over the stone and not the embankment. The outlet shall be configured as noted in Plate 3.13-2.

### Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Plate 3.13-1. Side slopes of the embankment shall be 2:1 or flatter.

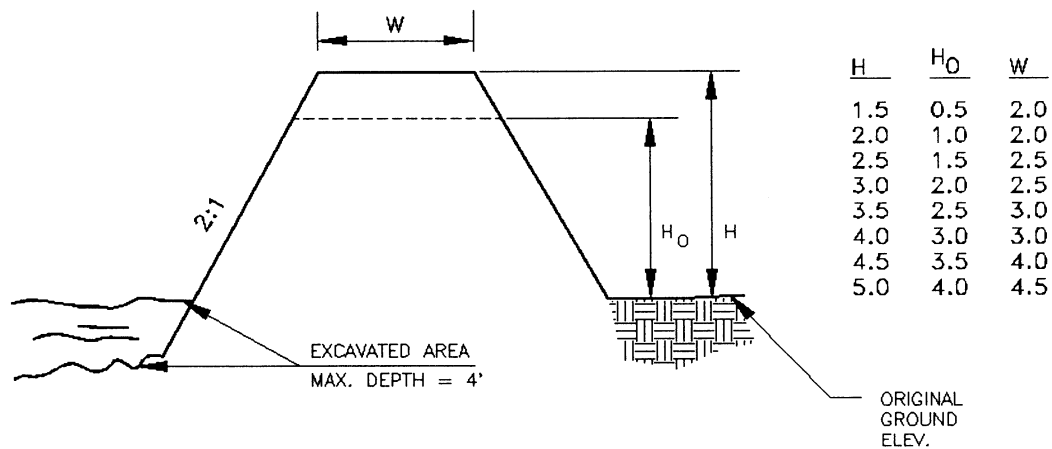
### Removal

Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded and stabilized after removal.

### Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat.
2. Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 6-inch layers by traversing with construction equipment.

*MINIMUM TOP WIDTH (W)  
REQUIRED FOR SEDIMENT  
TRAP EMBANKMENTS  
ACCORDING TO HEIGHT OF  
EMBANKMENT (FEET)*



Source: Va. DSWC

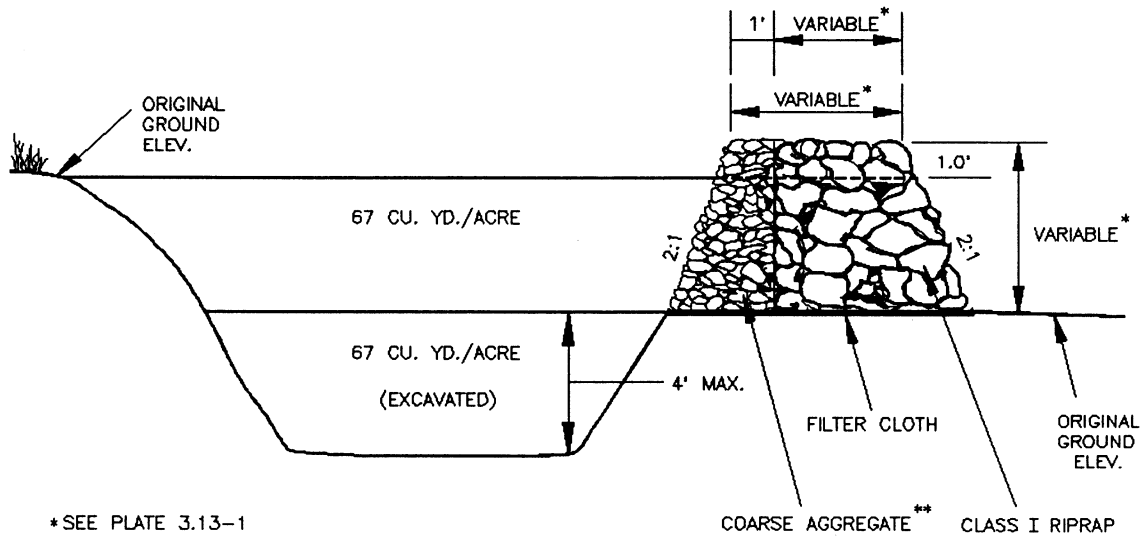
Plate 3.13-1

3. The earthen embankment shall be seeded with temporary or permanent vegetation (see Std. & Spec.'s 3.31 and 3.32) immediately after installation.
4. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.
5. The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.
6. All cut and fill slopes shall be 2:1 or flatter (except for excavated, wet storage area which may be at a maximum 1:1 grade).

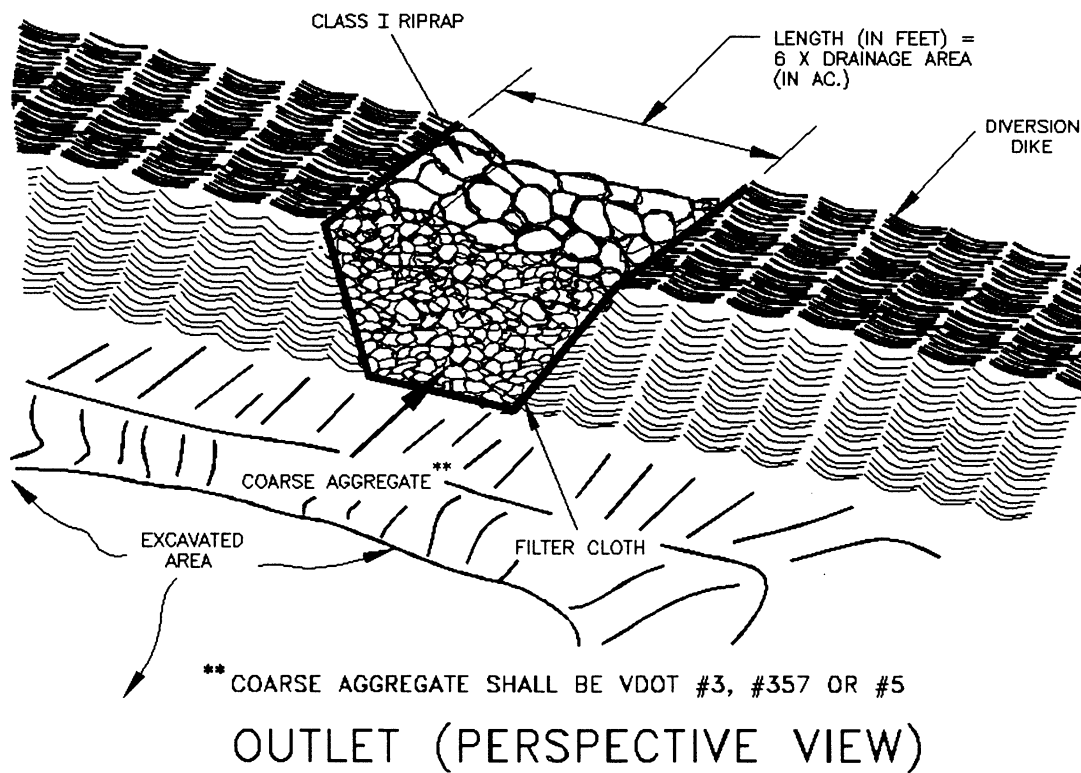
### Maintenance

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design volume of the wet storage. Sediment removal from the basin shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.
2. Filter stone shall be regularly checked to ensure that filtration performance is maintained. Stone choked with sediment shall be removed and cleaned or replaced.
3. The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 1 foot below the top of the embankment.

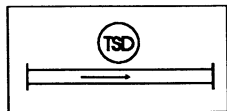
# TEMPORARY SEDIMENT TRAP



## CROSS SECTION OF OUTLET



## STD &amp; SPEC 3.15



## TEMPORARY SLOPE DRAIN

Definition

A flexible tubing or conduit extending from the top to the bottom of a cut or fill slope.

Purpose

To temporarily conduct concentrated stormwater runoff safely down the face of a cut or fill slope without causing erosion on or below the slope.

Conditions Where Practice Applies

On cut or fill slopes where there is a potential for upslope flows to move over the face of the slope causing erosion and preventing adequate stabilization.



### Planning Considerations

There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period, the slope is usually not stabilized and is particularly vulnerable to erosion. This situation also occurs on slope construction which is temporarily delayed before final grade is reached. Temporary slope drains can provide valuable protection of exposed slopes until permanent drainage structures can be installed or vegetation can be established.

Temporary slope drains can be used in conjunction with diversion dikes to convey runoff from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly, since their failure will often result in severe gully erosion on the site and sedimentation below the slope. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely.

### Design Criteria

#### Drainage Area

The maximum allowable drainage area per slope drain is 5 acres.

#### Flexible Conduit

The slope drain shall consist of heavy-duty, flexible material designed for this purpose. The diameter of the slope drain shall be equal over its entire length. Reinforced hold-down grommets shall be spaced at 10-foot (or less) intervals. Slope drains shall be sized as listed in Table 3.15-A.

#### Entrance Sections

The entrance to the slope drain shall consist of a standard VDOT flared end-section for metal pipe culverts (see Plates 3.15-2 and 3.15-3) with appropriate inlet protection as set forth in CULVERT INLET PROTECTION, Std. & Spec. 3.08. If ponding will cause a problem at the entrance and make such protection impractical, appropriate sediment-removing measures shall be taken at the outlet of the pipe. Extension collars shall consist of 12-inch long corrugated metal pipe. Watertight fittings shall be provided (see Plate 3.15-1).

**Note:** End-sections made of heavy-duty, flexible material may be utilized if determined by the Plan-Approving Authority to provide a stable inlet or outlet section.

TABLE 3.15-A	
SIZE OF SLOPE DRAIN	
<u>Maximum Drainage Area (acres)</u>	<u>Pipe Diameter (inches)</u>
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

Source: Va. DSWC

### Dike Design

An earthen dike shall be used to direct stormwater runoff into the temporary slope drain and shall be constructed as set forth in DIVERSION, Std. & Spec. 3.12. See Plate 3.15-1 for placement of dike in relation to the slope drain.

The height of the dike at the centerline of the inlet shall be equal to the diameter of the pipe plus 6 inches. Where the dike height is greater than 18 inches at the inlet, it shall be sloped at the rate of 3:1 or flatter to connect with the remainder of the dike (see Plate 3.15-1).

### Outlet Protection

The outlet of the slope drain must be protected from erosion as set forth in OUTLET PROTECTION, Std. & Spec. 3.18.

### Construction Specifications

1. The measure shall be placed on undisturbed soil or well-compacted fill.
2. The entrance section shall slope toward the slope drain at the minimum rate of 1/2-inch per foot.
3. The soil around and under the entrance section shall be hand-tamped in 8-inch lifts to the top of the dike to prevent piping failure around the inlet.

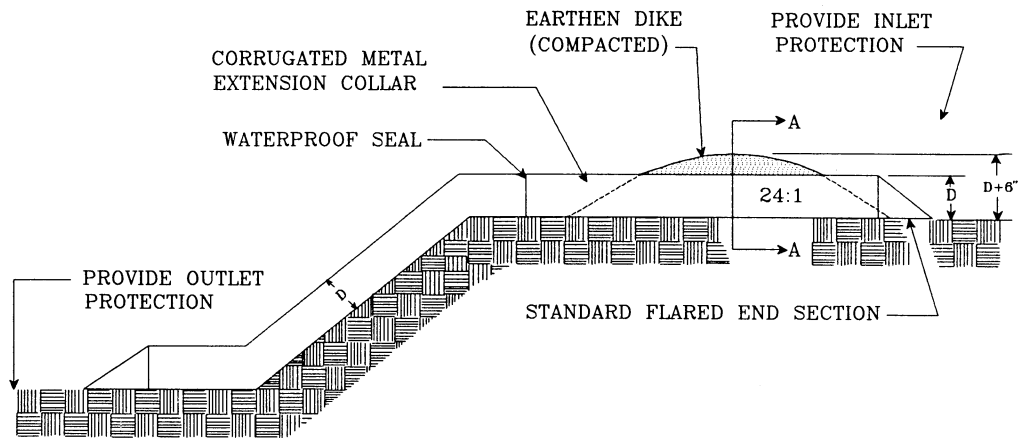
4. The slope drain shall be securely staked to the slope at the grommets provided.
5. The slope drain sections shall be securely fastened together and have watertight fittings.
6. Install CULVERT INLET PROTECTION and OUTLET PROTECTION as per Std. & Spec.'s 3.08 and 3.18, respectively.

#### Maintenance

The slope drain structure shall be inspected weekly and after every storm, and repairs made if necessary. The contractor should avoid the placement of any material on and prevent construction traffic across the slope drain.

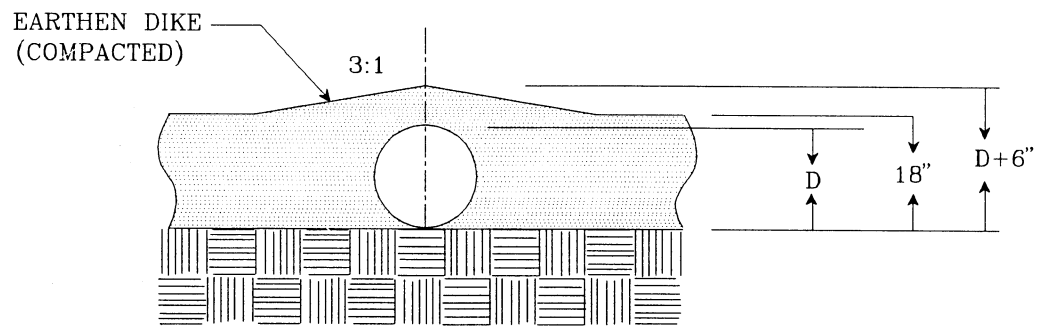


# TEMPORARY SLOPE DRAIN



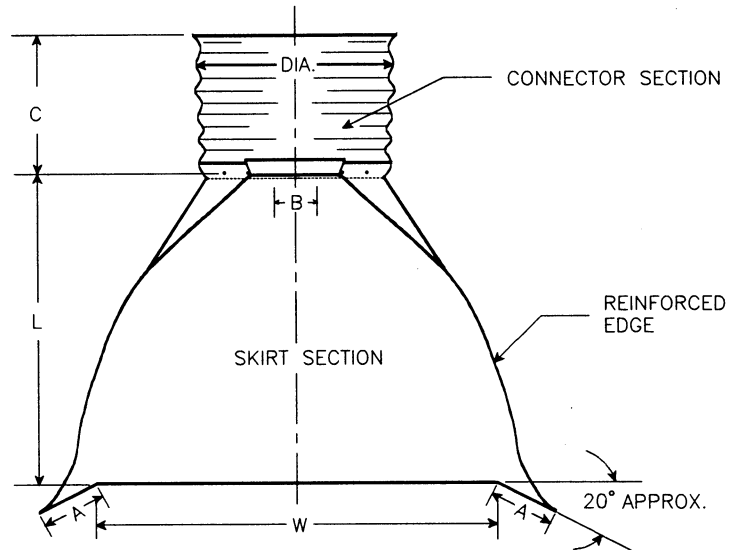
SECTION VIEW

NOTE: SEDIMENT MAY BE CONTROLLED AT OUTLET IF UPLAND PONDING  
WILL CREATE PROBLEMS



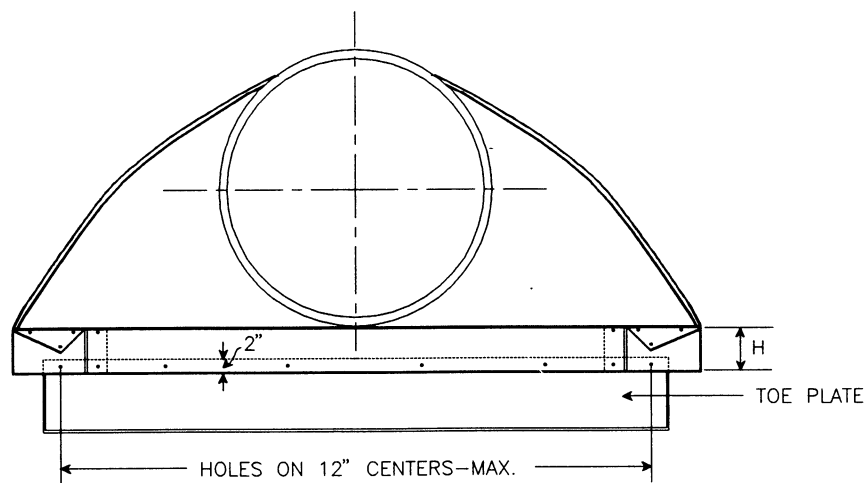
SECTION A - A

# FLARED END-SECTION



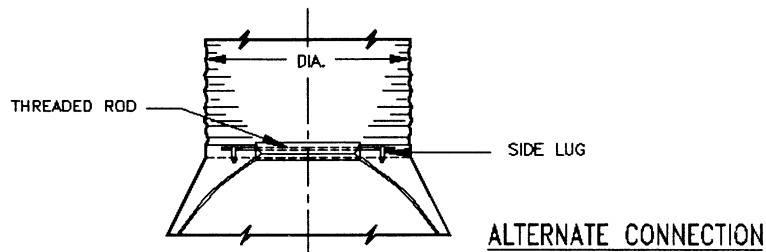
PLAN

WHERE FLARED END-SECTIONS ARE TO BE USED WITH BITUMINOUS COATED AND PAVED METAL PIPE, THEY ARE TO BE GALVANIZED ONLY.



ELEVATION

## FLARED END-SECTION (CONTINUED)



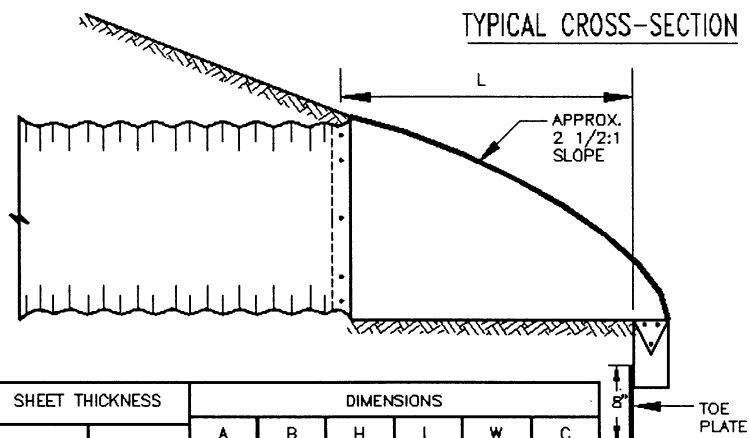
TOE PLATE, WHERE NEEDED, TO BE PUNCHED TO MATCH IN SKIRT LIP. 3/8" GALV. BOLTS TO BE FURNISHED. LENGTH OF TOE PLATE IS  $W + 10"$  FOR 12" TO 30" DIA. PIPE AND  $W + 22"$  FOR 36" TO 60" DIA. PIPE.

SKIRT SECTION FOR 12" TO 30" DIA. PIPE TO BE MADE IN ONE PIECE.

SKIRT SECTION FOR 36" TO 54" DIA. PIPE MAY BE MADE FROM TWO SHEETS JOINED BY RIVETING OR BOLTING ON CENTER LINE, 60" MAY BE CONSTRUCTED IN 3 PIECES.

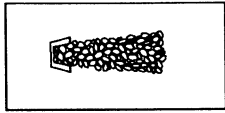
CONNECTOR SECTION, CORNER PLATE AND TOE PLATE TO BE SAME SHEET THICKNESS AS SKIRT.

END-SECTIONS AND FITTINGS ARE TO BE GALVANIZED STEEL OR ALUMINUM ALLOY FOR USE WITH LIKE PIPE.



PIPE DIA.	SHEET THICKNESS		DIMENSIONS					
	STEEL	ALUMINUM	A 1" TOL.	B MAX.	H 1" TOL.	L 1 1/2" TOL.	W 2" TOL.	C
12"	.064"	.060"	6"	6"	6"	21"	24"	24"
15"	.064"	.060"	7"	8"	6"	26"	30"	24"
18"	.064"	.060"	8"	10"	6"	31"	36"	24"
21"	.064"	.060"	10"	12"	6"	36"	42"	24"
24"	.064"	.060"	10"	13"	6"	41"	48"	24"
27"/30"	.064"	.075"	12"	16"	8"	51"	60"	24"
36"	.064"	.075"	14"	19"	9"	60"	72"	36"
42"	.064"	.105"	16"	22"	11"	69"	84"	36"
48"	.064"	.105"	18"	27"	12"	78"	90"	24"
54"	.064" /.079"	.105"	18"	30"	12"	84"	102"	36"
60"	.064" /.109"	.105" /.135"	18"	33"	12"	87"	114"	36"

## STD &amp; SPEC 3.18



## OUTLET PROTECTION

Definition

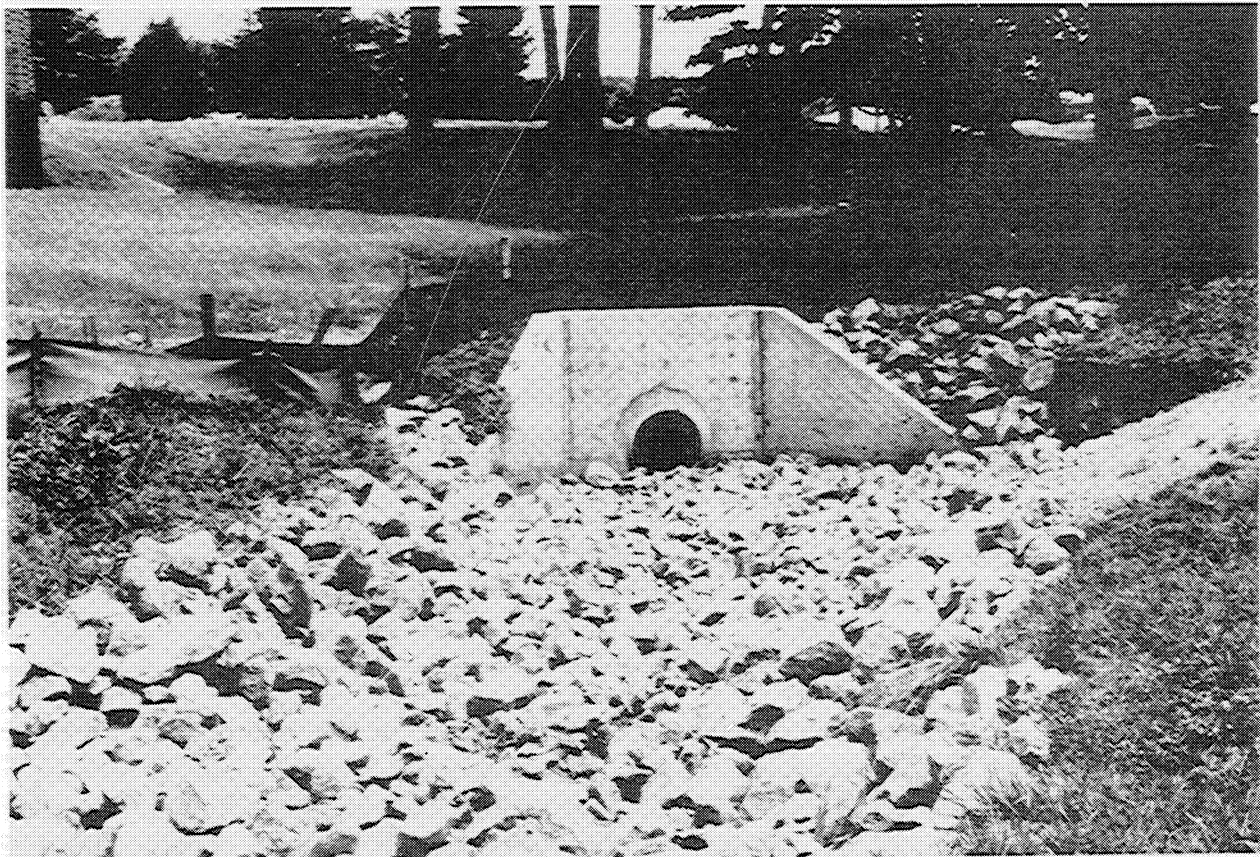
Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets of pipes or paved channel sections.

Purpose

To prevent scour at stormwater outlets, to protect the outlet structure, and to minimize the potential for downstream erosion by reducing the velocity and energy of concentrated stormwater flows.

Conditions Where Practice Applies

Applicable to the outlets of all pipes and engineered channel sections.



### Planning Considerations

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level. Criteria for designing such an apron are contained in this practice. Sample problems of outlet protection design are contained in Appendix 3.18-a.

Where flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for stilling basins may be found in the following sources:

1. Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, U. S. Department of Transportation, Federal Highway Administration (83).
2. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, U.S. Department of the Interior - Bureau of Reclamation, (74).

Note: Both of the above are available from the U.S. Government Printing Office.

### Design Criteria

The design of structurally lined aprons at the outlets of pipes and paved channel sections applies to the immediate area or reach below the pipe or channel and does not apply to continuous rock linings of channels or streams (See STORMWATER CONVEYANCE CHANNEL, Std. & Spec. 3.17). Notably, pipe or channel outlets at the top of cut slopes or on slopes steeper than 10% should not be protected using just outlet protection as a result of the reconcentration and large velocity of flow encountered as the flow leaves the structural apron. Outlet protection shall be designed according to the following criteria:

#### Pipe Outlets

(See Plate 3.18-1)

1. Tailwater depth: The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth (see Chapter 5, Engineering Calculations). If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a

Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition. Notably, in most cases where post-development stormwater runoff has been concentrated or increased, MS #19 will be satisfied only by outfall into a defined channel.

2. Apron length: The apron length shall be determined from the curves according to the tailwater condition:

Minimum Tailwater - Use Plate 3.18-3.

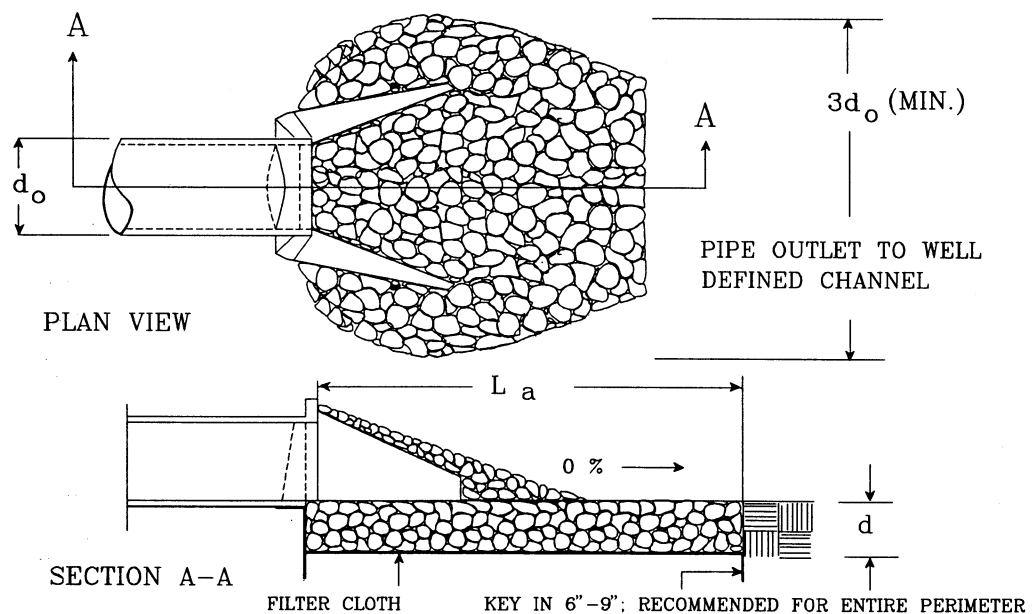
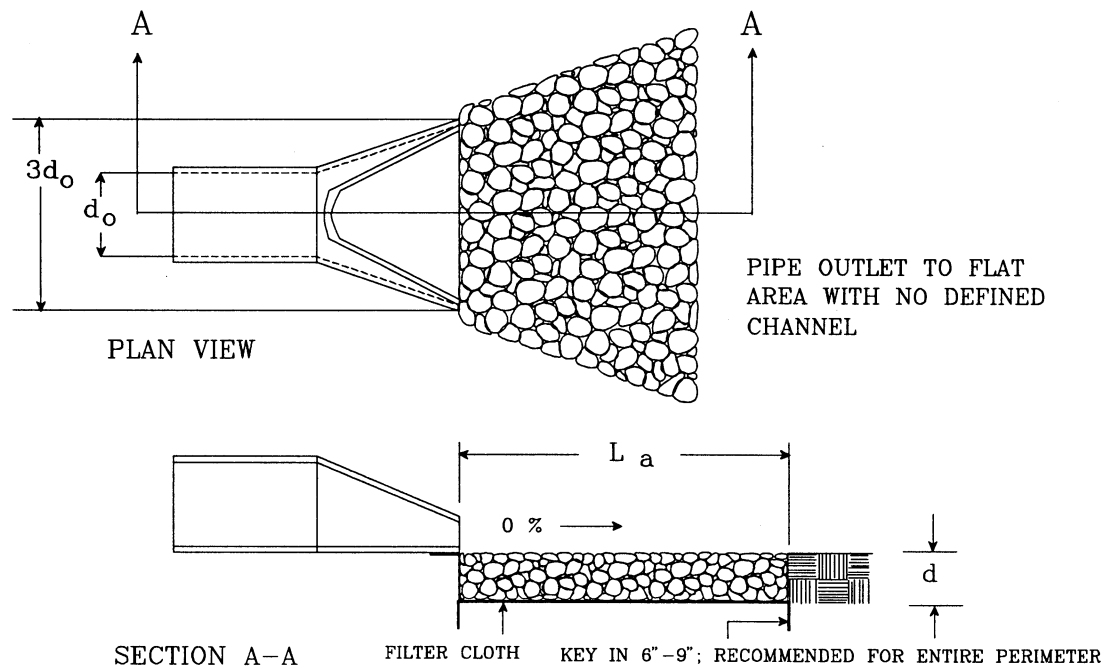
Maximum Tailwater - Use Plate 3.18-4.

3. Apron width: When the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less).

If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

- a. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.
  - b. For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron.
  - c. For a Maximum Tailwater Condition, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.
4. Bottom grade: The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.
  5. Side slopes: If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal: vertical).
  6. Alignment: The apron shall be located so there are not bends in the horizontal alignment.
  7. Materials: The apron may be lined with riprap, grouted riprap, concrete, or gabion baskets. The median sized stone for riprap shall be determined from the curves in Appendix 3.18-a (Plates 3.18-3 and 3.18-4) according to the tailwater condition. The gradation, quality and placement of riprap shall conform to Std. & Spec. 3.19, RIPRAP.

## PIPE OUTLET CONDITIONS



- NOTES: 1. APRON LINING MAY BE RIPRAP, GROUTED RIPRAP, GABION BASKET, OR CONCRETE.  
 2.  $L_a$  IS THE LENGTH OF THE RIPRAP APRON AS CALCULATED USING PLATES 3.18-3 AND 3.18-4.  
 3.  $d = 1.5$  TIMES THE MAXIMUM STONE DIAMETER, BUT NOT LESS THAN 6 INCHES.

8. Filter cloth: In all cases, filter cloth shall be placed between the riprap and the underlying soil to prevent soil movement into and through the riprap. The material must meet or exceed the physical properties for filter cloth found in Std. & Spec. 3.19, RIPRAP. See Plate 3.18-1 for orientation details.

### Paved Channel Outlets

(See Plate 3.18-2)

1. The flow velocity at the outlet of paved channels flowing at design capacity must not exceed the permissible velocity of the receiving channel (see Tables 3.18-A and 3.18-B)
2. The end of the paved channel shall merge smoothly with the receiving channel section. There shall be no overfall at the end of the paved section. Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a transition section shall be provided. The maximum side divergence of the transition shall be 1 in 3F where;

$$F = \frac{V}{\sqrt{gd}}$$

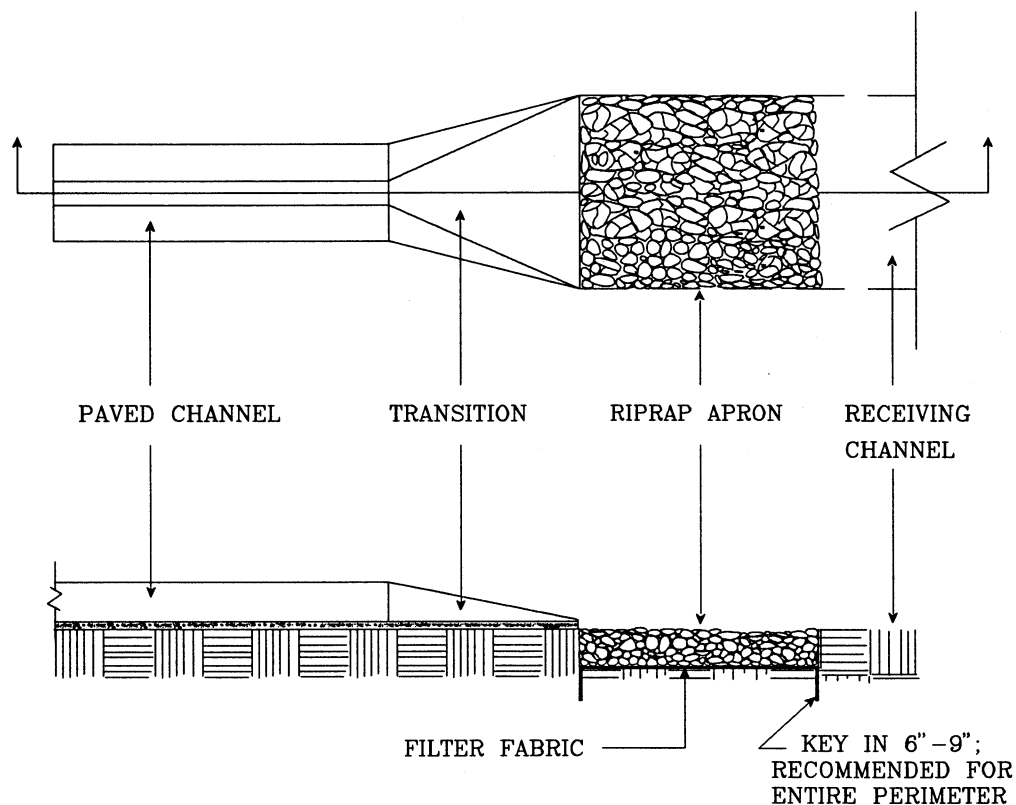
where,

F	=	Froude number
V	=	Velocity at beginning of transition (ft./sec.)
d	=	depth of flow at beginning of transition (ft.)
g	=	32.2 ft./sec. <sup>2</sup>

3. Bends or curves in the horizontal alignment at the transition are not allowed unless the Froude number (F) is 1.0 or less, or the section is specifically designed for turbulent flow.



## PAVED CHANNEL OUTLET



### NOTES:

1. RIPRAP APRON REDUCES THE FLOW VELOCITY BELOW THE PERMISSIBLE VELOCITY OF THE NATURAL RECEIVING CHANNEL.
2. TRANSITION SIDE DIVERGENCE IS 1 IN 3F, WHERE

$$F = \text{FROUDE NUMBER} = \frac{V}{\sqrt{gd}}, \text{ WHERE}$$

V = VELOCITY AT THE BEGINING OF THE TRANSITION

d = DEPTH OF FLOW AT THE BEGINING OF THE TRANSITION

$$g = 32.2 \text{ ft./sec}^2$$

**TABLE 3.18-A****PERMISSIBLE VELOCITIES FOR GRASS-LINED CHANNELS**

Channel Slope	Lining	Velocity* (ft./sec.)
0 - 0.5%	Bermudagrass	6
	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains Temporary vegetation	2.5
5 - 10%	Bermudagrass	5
	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
	Bermudagrass	4
Greater than 10%	Reed canarygrass Tall fescue Kentucky bluegrass	3
* For highly erodible soils, decrease permissible velocities by 25%.		

Source: Soil and Water Conservation Engineering, Schwab, et. al. and American Society of Civil Engineers

**TABLE 3.18-B?****PERMISSIBLE VELOCITIES FOR EARTH LININGS**

<u>Soil Types</u>	<u>Permissible Velocities (ft./sec.)</u>
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	5.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Plans	6.0

Source: Soil and Water Conservation Engineering, Schwab, et.al. and American Society of Civil Engineers

## APPENDIX 3.18-a

Sample Problems: Outlet Protection DesignExample 1

**Given:** An 18-inch pipe discharges 24 cfs at design capacity onto a grassy slope (no defined channel).

**Find:** The required length, width and median stone size ( $d_{50}$ ) for a riprap-lined apron.

**Solution:**

1. Since the pipe discharges onto a grassy slope with no defined channel, a Minimum Tailwater Condition may be assumed.
2. From Plate 3.18-3, an apron length ( $L_a$ ) of 20 feet and a median stone size ( $d_{50}$ ) of 0.8 ft. are determined.
3. The upstream apron width equals three times the pipe diameter;  $3 \times 1.5 \text{ ft} = \underline{4.5 \text{ ft.}}$
4. The downstream apron width equals the apron length plus the pipe diameter;  $20 \text{ ft.} + 1.5 \text{ ft.} = \underline{21.5 \text{ ft.}}$

Example 2

**Given:** The pipe in example No. 1 discharges into a channel with a triangular cross-section, 2 feet deep and 2:1 side slopes. The channel has a 2% slope and an "n" factor of .045.

**Find:** The required length, width and the median stone size ( $d_{50}$ ) for a riprap lining.

**Solution:**

1. Determine the tailwater depth using Manning's Equation.

$$Q = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} A$$

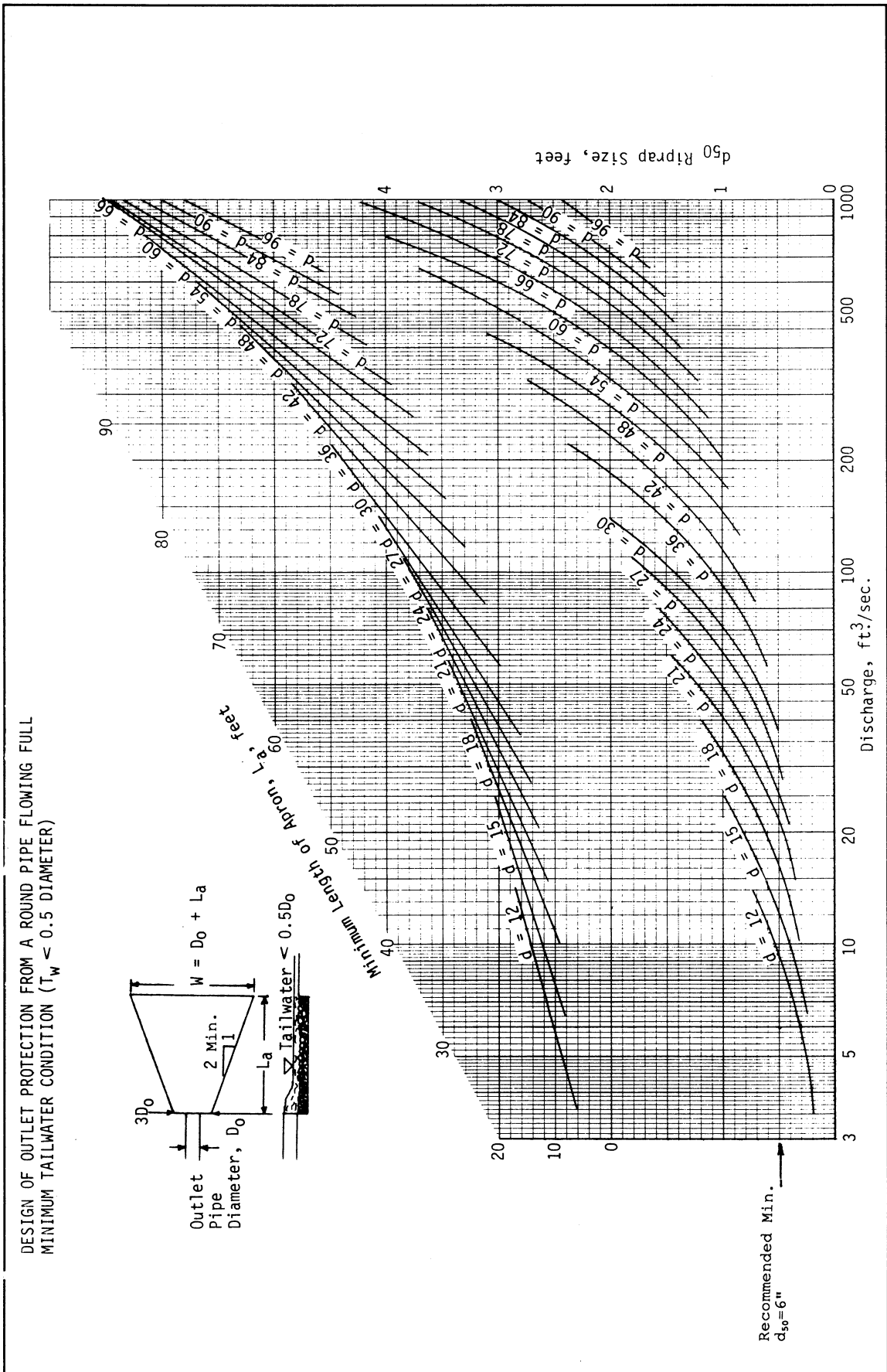
$$24 = \frac{1.49}{.045} \left( \frac{2d}{2\sqrt{2^2+1}} \right)^{\frac{2}{3}} (.02)^{\frac{1}{2}} (2d^2)$$

where,

d = depth of tailwater  
d = 1.74 ft. \*

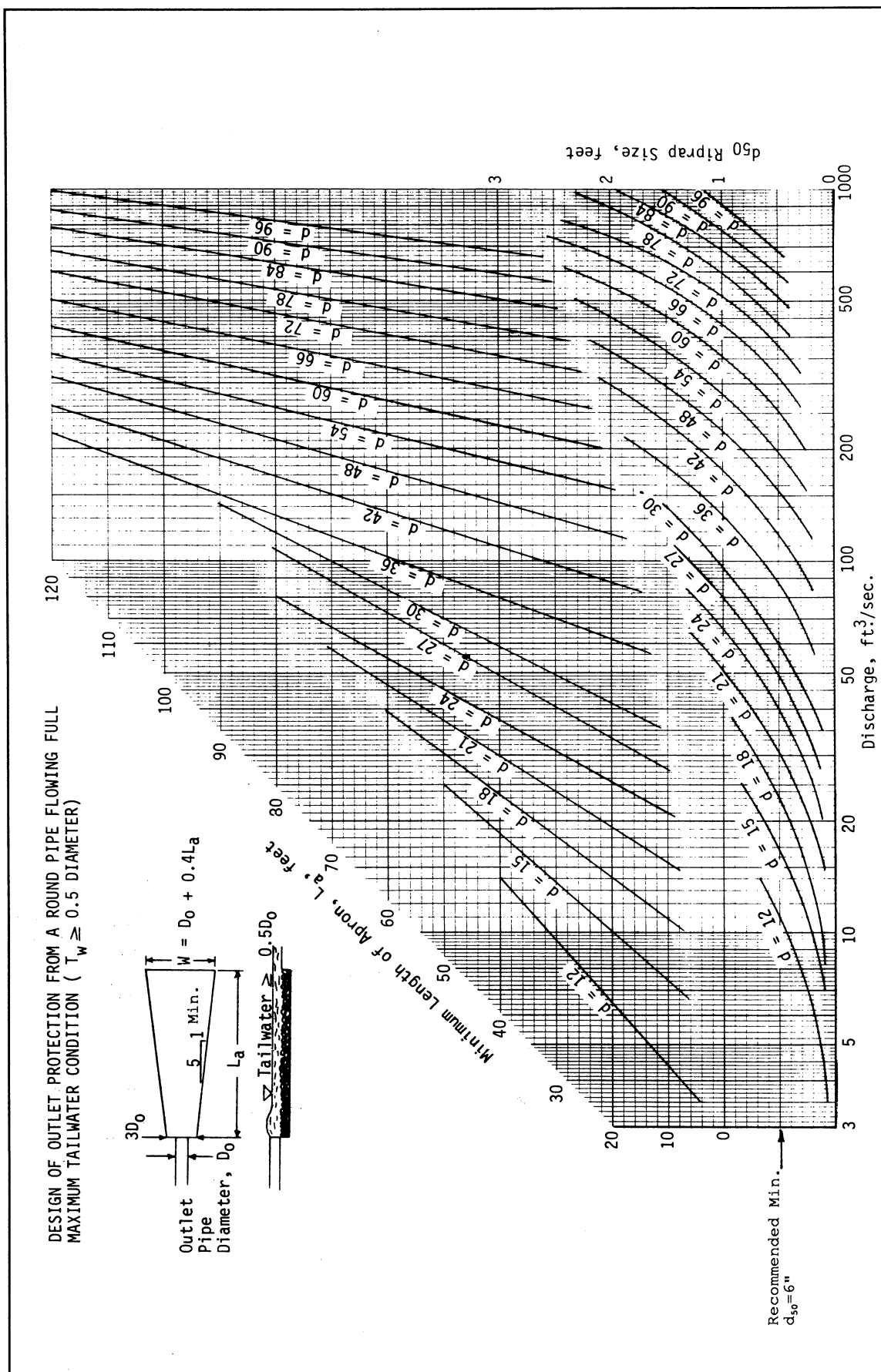
\* since d is greater than half the pipe diameter, a Maximum Tailwater Condition exists.

2. From Plate 3.18-4, a median stone size ( $d_{50}$ ) of 0.5 ft. and an apron length ( $L_a$ ) of 41 ft. is determined.
3. The entire channel cross-section should be lined since the maximum tailwater depth is within one foot of the top of the channel.



Source: USDA-SCS

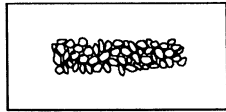
Plate 3.18-3



Source: USDA-SCS

Plate 3.18-4

## STD &amp; SPEC 3.19



## RIPRAP

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone with filter fabric or granular underlining.

Purposes

1. To protect the soil from the erosive forces of concentrated runoff.
2. To slow the velocity of concentrated runoff while enhancing the potential for infiltration.
3. To stabilize slopes with seepage problems and/or non-cohesive soils.





### Conditions Where Practice Applies

Wherever soil and water interface and the soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at stormdrain outlets, on channel banks and/or bottoms, roadside ditches, drop structures, at the toe of slopes, as transition from concrete channels to vegetated channels, etc.

### Planning Considerations

#### Graded vs. Uniform Riprap

Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand or mechanical labor.

Riprap sizes can be designed by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be angular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table 3.19-A lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 165 lbs./ft<sup>3</sup>.

Since graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in the mixture for which some percentage, by weight, will be smaller. For example,  $d_{85}$  refers to a mixture of stones in which 85% of the stone by weight would be smaller than the diameter specified. Most designs are based on  $d_{50}$ . In other words, the design is based on the average size of stone in the mixture. Table 3.19-B lists VDOT standard graded riprap sizes by diameter the weight of the stone.

To ensure that stone of substantial weight is used when implementing riprap structures, specified weight ranges for individual stones and composition requirements should be followed. Such guidelines will help to prevent inadequate stone from being used in construction of the measures and will promote more consistent stone classification statewide. Table 3.19-C notes these requirements.

TABLE 3.19-A

## SIZE OF RIPRAP STONES

Weight (lbs.)	Mean Spherical Diameter (ft.)	Angular Shape:	
		Length (ft.)	Width, Height (ft.)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1,000	2.2	3.7	1.25
1,500	2.6	4.7	1.5
2,000	2.75	5.4	1.8
4,000	3.6	6.0	2.0
6,000	4.0	6.9	2.3
8,000	4.5	7.6	2.5
20,000	6.1	10.0	3.3

Source: VDOT Drainage Manual

### Sequence of Construction

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

### Design Criteria

#### Gradation

The riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% of the mixture by weight shall be larger than the  $d_{50}$  size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be  $1\frac{1}{2}$  times the  $d_{50}$  size.

**TABLE 3.19-B**  
**GRADED RIPRAP - DESIGN VALUES**

<u>Riprap Class</u>	<u>D<sub>15</sub> Weight (lbs.)</u>	<u>Mean D<sub>15</sub> Spherical Diameter (ft.)</u>	<u>Mean D<sub>50</sub> Spherical Diameter (ft.)</u>
Class AI	25	0.7	0.9
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1,500	2.6	2.8
Type II	6,000	4.0	4.5

Source: VDOT Drainage Manual

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.

#### Thickness

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 6 inches.

#### Quality of Stone

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

**TABLE 3.19-C**  
**GRADED RIPRAP - WEIGHT ANALYSIS**

<u>Riprap Class/Type</u>	<u>Weight Range* (lbs.)</u>	<u>Requirements for Stone Mixture</u>
Class AI	25-75	Max. 10% > 75 lbs.
Class I	50-150	60% > 100 lbs.
Class II	150-500	50% > 300 lbs.
Class III	500-1,500	50% > 900 lbs.
Type I	1,500-4,000	Av. wt. = 2,000 lbs.
Type II	6,000-20,000	Av. wt. = 8,000 lbs.

\* In all classes/types of riprap, a maximum 10% of the stone in the mixture may weigh less than the lower end of the range.

Source: Adapted from VDOT Road and Bridge Specifications

#### Filter Fabric Underlining

A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. Table 3.19-D notes the minimum physical properties of the filter fabric.

Filter fabric shall not be used on slopes greater than 1½:1 as slippage may occur and should be used in conjunction with a layer of coarse aggregate (granular filter blanket is described below) when the riprap to be placed is Class II or larger.

#### Granular Filter

Although the filter cloth underlining or bedding is the preferred method of installation, a granular (stone) bedding is a viable option when the following relationship exists:

$$\frac{d_{15} \text{ filter}}{d_{85} \text{ base}} < 5 < \frac{d_{15} \text{ filter}}{d_{15} \text{ base}} < 40$$

and,

$$\frac{d_{50} \text{ filter}}{d_{50} \text{ base}} < 40$$

In these relationships, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. In some cases, more than one layer of filter material may be needed. Each layer of filter material should be approximately 6-inches thick.

**TABLE 3.19-D**

**REQUIREMENTS FOR FILTER FABRIC USED WITH RIPRAP**

<u>Physical Property</u>	<u>Test Method</u>	<u>Requirements</u>
Equivalent Opening Size	Corps of Engineers CWO 2215-77	Equal or greater than U.S. No. 50 sieve
Tensile Strength* @ 20% (maximum)	VTM-52	30 lbs./linear in. (minimum)
Puncture Strength	ASTM D751*	80 lbs. (minimum)

\* Tension testing machine with ring clamp, steel ball replaced with 5/16 diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

Seams shall be equal in strength to basic material.

Additional fabric material or non-corrosive steel wire may be incorporated into the fabric to increase overall strength.

Source: VDOT Road and Bridge Specifications

### Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structure are contained in OUTLET PROTECTION (Std. & Spec. 3.18). A filter fabric underlining is required for riprap used as outlet protection.

### Riprap for Channel Stabilization

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized. The design procedure in Appendix 3.19-a, which is extracted from the Federal Highway Administration's Design of Stable Channels with Flexible Linings (82), shall be used. This method establishes the stability of the rock material relative to the forces exerted upon it.

Riprap shall extend up the banks of the channel to a height equal to the maximum depth of flow or to a point where vegetation can be established to adequately protect the channel.

The riprap size to be used in a channel bend shall extend upstream from the point of curvature and downstream from the bottom of the channel to a minimum depth equal to the thickness of the blanket and shall extend across the bottom of the channel the same distance (see Plate 3.19-1).

### Freeboard and Height of Bank

For riprapped and other lined channels, the height of channel lining above the water surface should be based on the size of the channel, the flow velocity, the curvature, inflows, wind action, flow regulation, etc.

The height of the bank above the water surface varies in a similar manner, depending on the above factors plus the type of soil.

Plate 3.19-2 is based on information developed by the U.S. Bureau of Reclamation for average freeboard and bank height in relation to channel capacity. This chart should be used by the designer to obtain a minimum freeboard for placement of riprap and top of bank.

### Riprap for Slope Stabilization

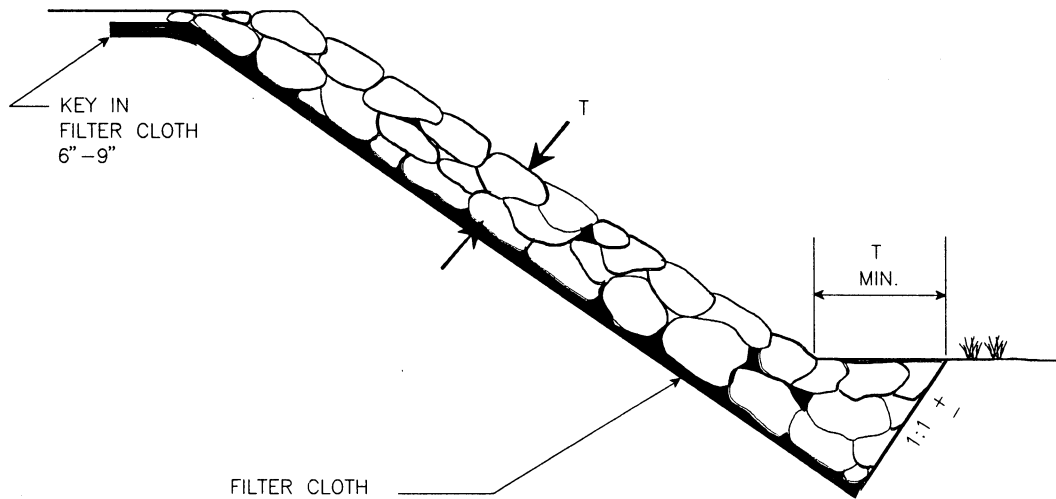
Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is greater than the gradient of the slope being stabilized (see Plate 3.19-5).

### Riprap for Lakes and Ponds Subject to Wave Action

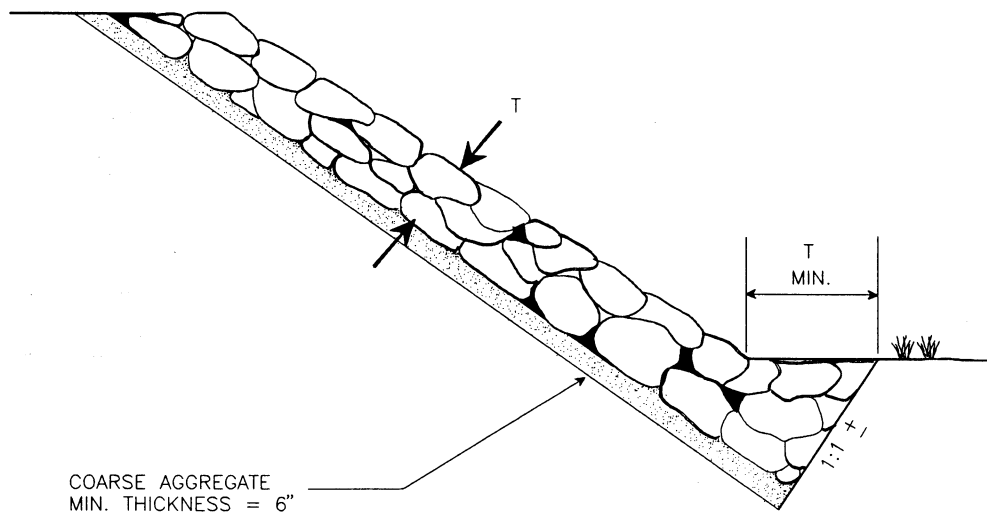
Riprap used for shoreline protection on lakes and ponds may be subject to wave action. The waves affecting the shoreline may be wind-driven or created by boat wakes. Consult

# *TOE REQUIREMENTS FOR BANK STABILIZATION*

## FILTER CLOTH UNDERLINER (PREFERRED)



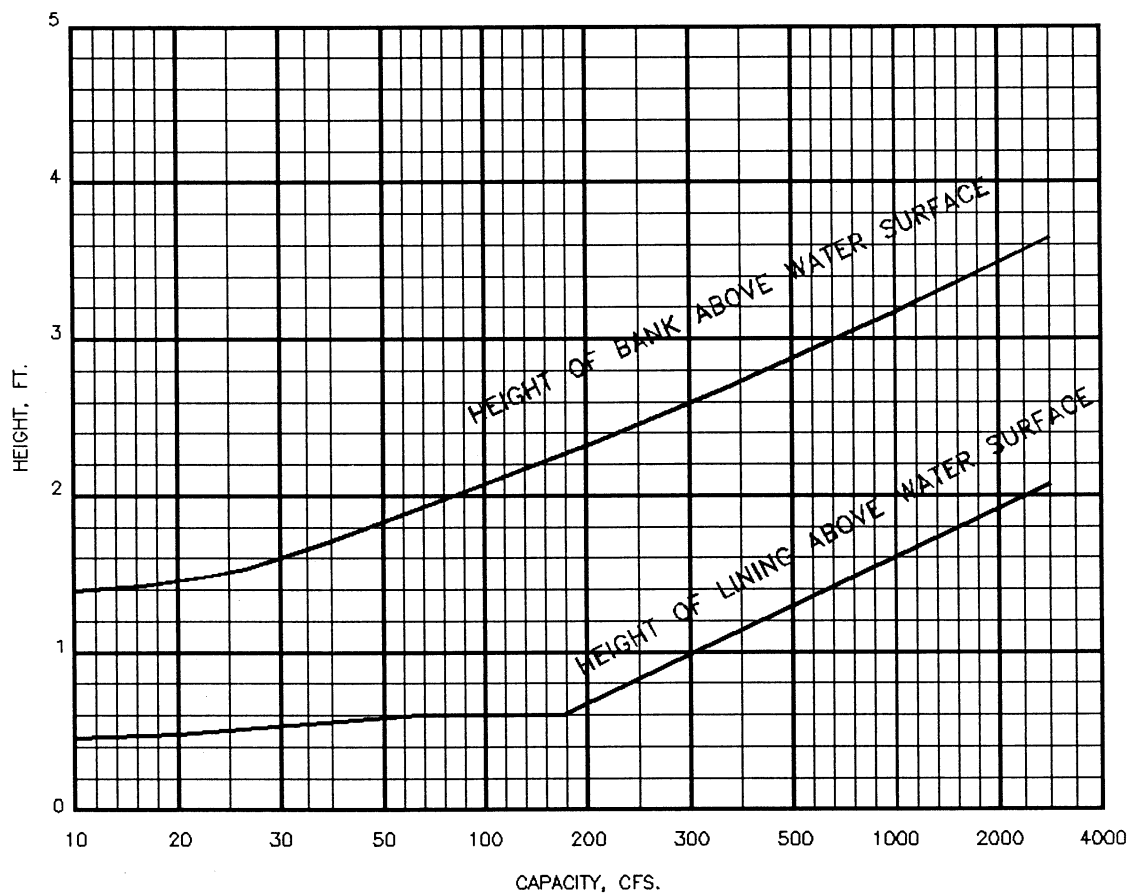
## GRANULAR FILTER



Source: Adapted from VDOT Drainage Manual

Plate 3.19-1

*RECOMMENDED FREEBOARD  
AND  
HEIGHT OF BANK OF  
LINED CHANNELS*



Source: U. S. Bureau of Reclamation

Plate 3.19-2



the latest edition of the VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action") for specific design criteria in determining the required size of stones and the design wave height for such an installation. Use the equations in Appendix 3.19-b to calculate other pertinent design parameters. For more in-depth design criteria concerning these installations, see the U.S. Army Corps of Engineers' Shore Protection Manual (59).

#### Riprap for Abrupt Channel Contractions

Refer to latest edition of VDOT Drainage Manual.

#### Riprap for Installations Subject to Tidal and Wave Action

The design of riprap structures for tidal areas is beyond the scope of the VESCL and VESCR. The DSWC's Shoreline Programs Bureau provides advice regarding minimum design parameters for these installations. Notably, a riprap design for shoreline protection in tidal areas must meet all applicable state and federal requirements and should be carried out by a qualified professional.

#### Construction Specifications

Subgrade Preparation: The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximately that of the surrounding undisturbed material. Brush, trees, stumps and other objectionable material shall be removed.

Filter Fabric or Granular Filter: Placement of the filter fabric should be done immediately after slope preparation. For granular filters, the stone should be spread in a uniform layer to the specified depth (normally 6 inches). Where more than one layer of filter material is used, the layer should be spread so that there is minimal mixing of the layers.

When installing geotextile filter cloths, the cloth should be placed directly on the prepared slope. The edges of the sheets should overlap by at least 12 inches. Anchor pins, 15 inches long, should be spaced every 3 feet along the overlap. The upper and lower ends of the cloth should be buried at least 12 inches. Care should be taken not to damage the cloth when placing the riprap. If damage occurs, that sheet should be removed and replaced. For large stone (Class II or greater), a 6-inch layer of granular filter will be necessary to prevent damage to the cloth.

Stone Placement: Placement of riprap should follow immediately after placement of the filter. The riprap should be placed so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods. The riprap should be placed to its full thickness in one operation. The riprap should not be placed in layers. The riprap should not be placed by dumping into chutes or similar methods which are likely to cause

segregation of the various stone sizes. Care should be taken not to dislodge the underlying material when placing the stones.

The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve the required grades and a good distribution of stone sizes. Final thickness of the riprap blanket should be within plus or minus 1/4 of the specified thickness.

#### Maintenance

Once a riprap installation has been completed, it should require very little maintenance. It should, however, be inspected periodically to determine if high flows have caused scour beneath the riprap or filter fabric or dislodged any of the stone. Care must be taken to properly control sediment-laden construction runoff which may drain to the point of the new installation. If repairs are needed, they should be accomplished immediately.

**APPENDIX 3.19-a****RIPRAP DESIGN IN CHANNEL**

The design method described below is adapted from Hydraulic Engineering Circular No. 15 of the Federal Highway Administration. It is applicable to both straight and curved sections of channel where the flow is tangent to the bank of the channel.

**Tangent Flow - Federal Highway Administration Method**

This design method determines a stable rock size for straight and curved sections of channels. It is assumed that the shape, depth of flow, and slope of the channel are known. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3:1, the stone size must be modified accordingly. The final design size will be stable on both sides of the channel and the bottom.

1. Enter Plate 3.19-3 with the maximum depth of flow (feet) and channel slope (feet/foot). Where the two lines intersect, choose the  $d_{50}$  size of stone. (Select the  $d_{50}$  for the diagonal line above the point of intersection).
2. If channel side slopes are steeper than 3:1, continue with step 3; if not, the procedure is complete.
3. Enter Plate 3.19-4 with the side slope and the base width to maximum depth ratio ( $B/d$ ). Where the two lines intersect, move horizontally left to read  $K_1$ .
4. Determine from Plate 3.19-5 the angle of repose for the  $d_{50}$  size of stone and the side slope of the channel. (Use  $42^\circ$  for  $d_{50}$  greater than 1.0. Do not use riprap on slopes steeper than the angle of repose for the size of stone).
5. Enter Plate 3.19-6 with the side slope of the channel and the angle of repose for the  $d_{50}$  size of stone. Where the two lines intersect, move vertically down to read  $k_2$ .
6. Compute  $d_{50} \times K_1/K_2 = d'_{50}$  to determine the correct size stone for the bottom and side slopes of straight sections of channel.

**For Curved Sections of Channel**

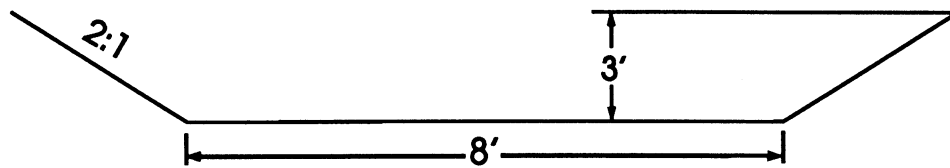
1. Compute the radius of the curve ( $R_o$ ), measured at the outside edge of the bottom.
2. Compute the ratio of the top width of the water surface ( $B_s$ ) to the radius of the curve ( $R_o$ ),  $B_s/R_o$ .
3. Enter Plate 3.19-7 with the ratio  $B_s/R_o$ . Move vertically until the curve is intersected. Move horizontally left to read  $K_3$ .

4. Compute  $d'_{50} \times K_3 = d_{50c}$  to determine the correct size stone for bottom and side slopes of the curved sections of channel.

### Example Problem

#### Given:

A trapezoidal channel 3 feet deep, 8 foot bottom width, 2:1 side slopes, and a 2% slope.



#### Calculate:

A stable riprap size for the bottom and side slopes of the channel.

#### Solution:

1. From Plate 3.19-3, for a 3-foot-deep channel on a 2% grade,  $d_{50} = 0.75$  feet or 9 inches.
2. Since the side slopes are steeper than 3:1, continue with step 3.
3. From Plate 3.19-4,  $B/d = 8/3 = 2.67$ ,  $Z = 2$ ,  $K_1 = 0.82$ .
4. From Plate 3.19-5, for  $d_{50} = 9$  inches,  $\phi = 41^\circ$ .
5. From Plate 3.19-6, for  $Z = 2$  and  $\phi = 41^\circ$ ,  $K_2 = 0.73$ .
6.  $d_{50} \times K_1/k_2 = d'_{50} = 0.75 \times 0.82/0.73 = 0.84$  feet.

$$0.84 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 10.08. \text{ Use } d'_{50} = 10 \text{ inches.}$$

Given:

The preceding channel has a curved section with a radius of 50 feet.

Calculate:

A stable riprap size for the bottom and side slopes of the curved section of channel.

Solution:

1.  $R_o = 50$  feet
2.  $B_s/R_o = 20/50 = 0.40$
3. From Plate 3.19-7, for  $B_s/R_o = 0.40$ ,  $K_3 = 1.1$
4.  $d'_{50} \times K_3 = 0.84 \times 1.1 = 0.92$  feet  
 $0.92 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 11.0.$

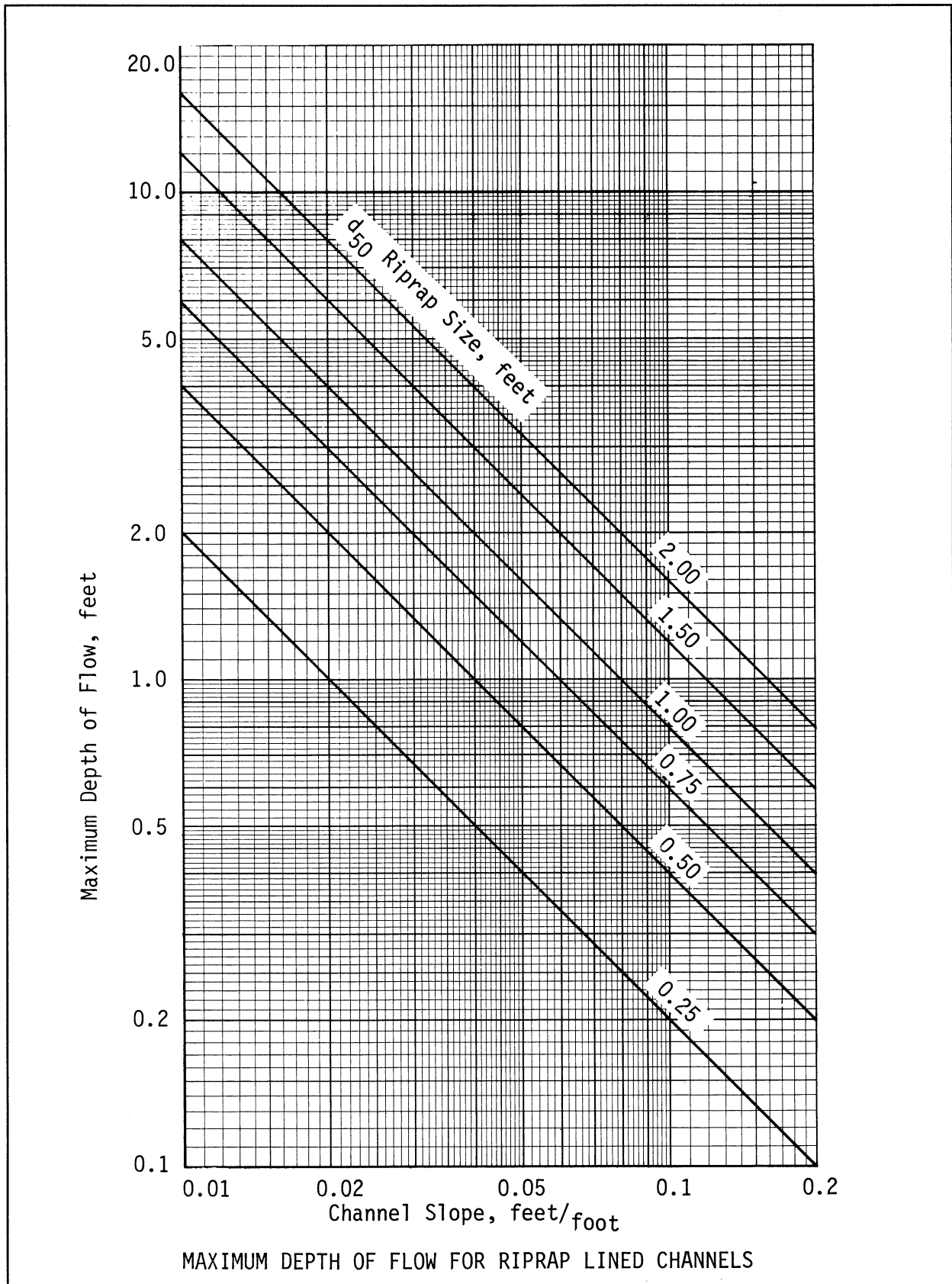
Source: VDOT Drainage Manual

Plate 3.19-3

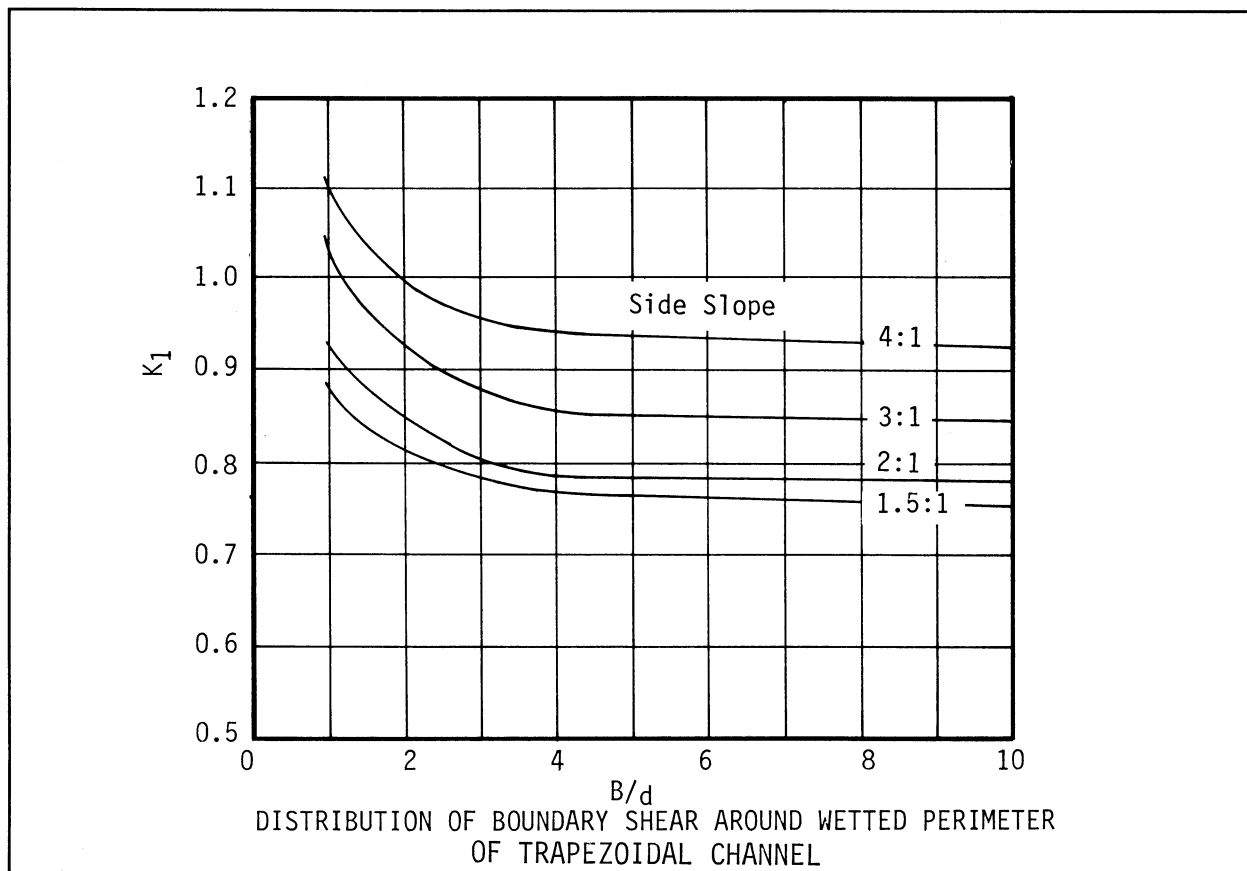
Source: VDOT Drainage Manual

Plate 3.19-4

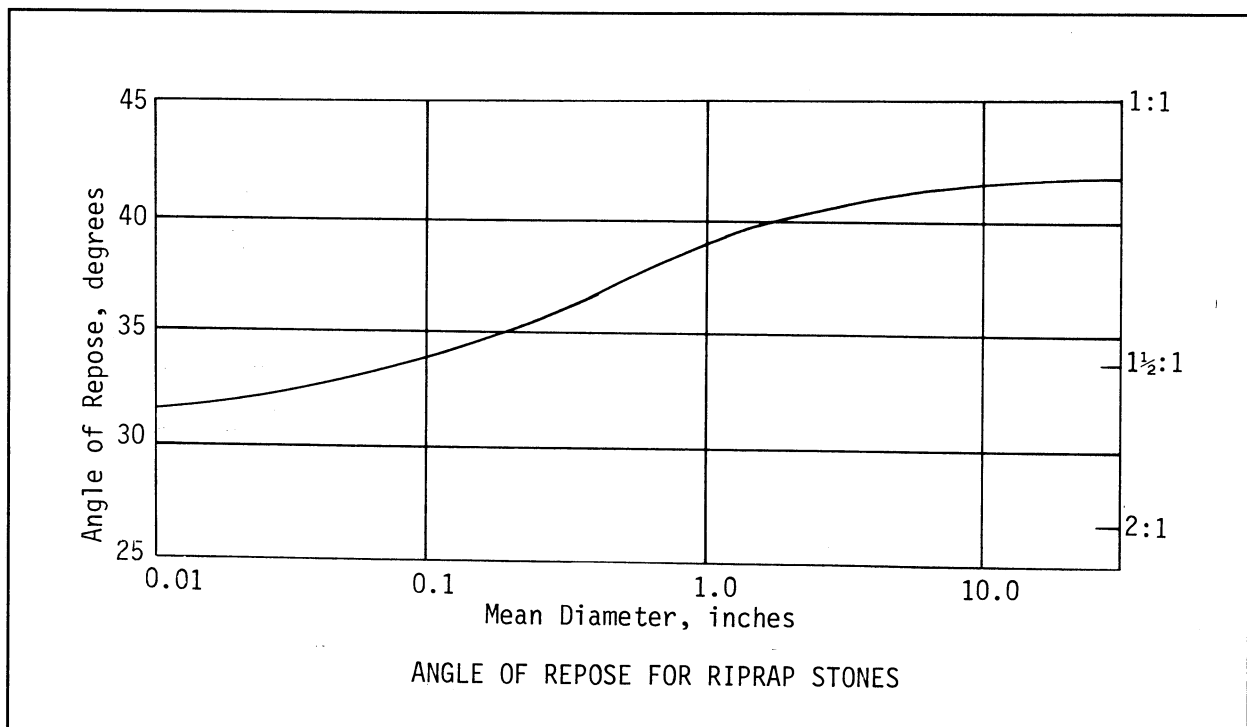
Source: VDOT Drainage Manual

Plate 3.19-5

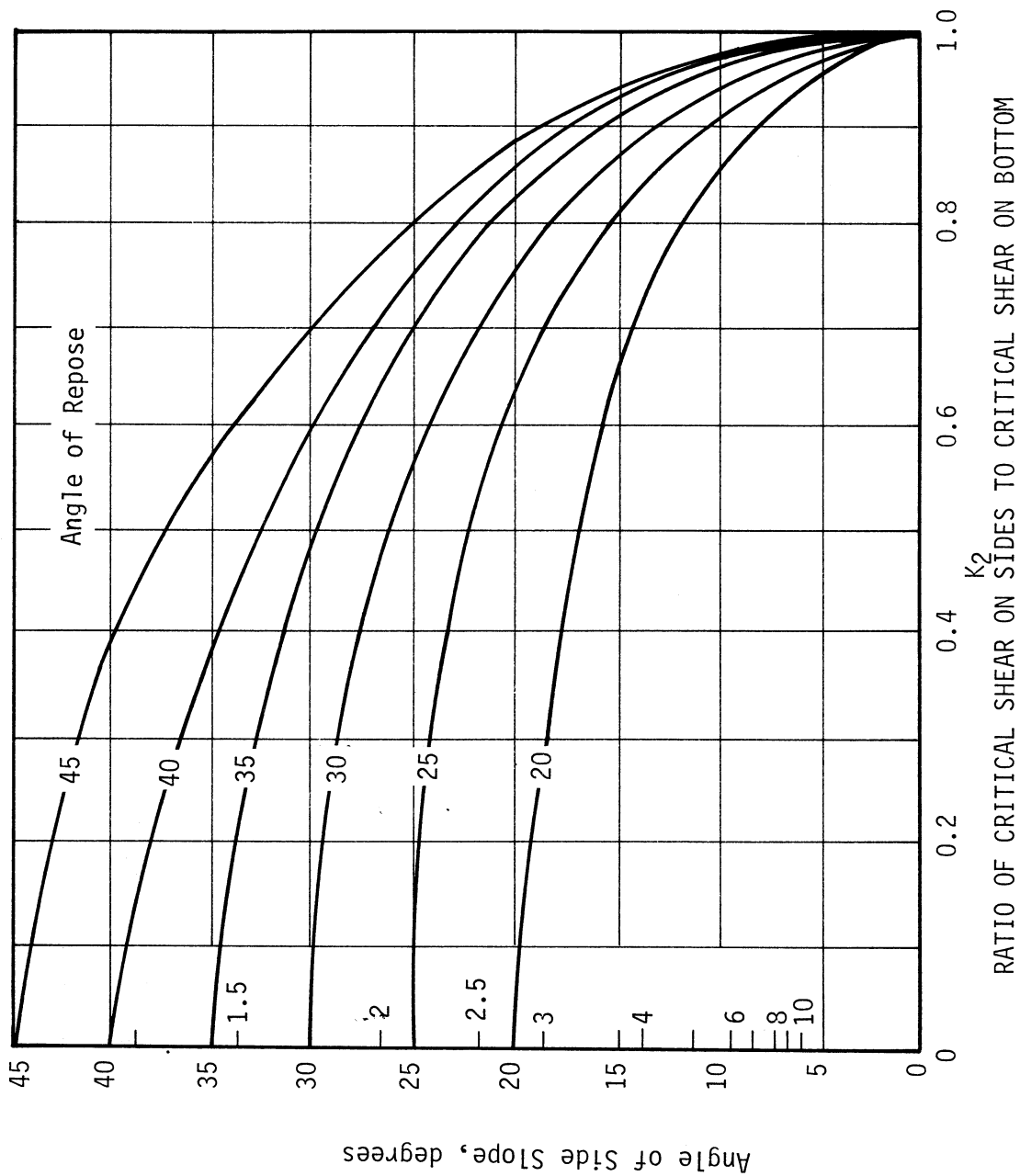
Source: VDOT Drainage Manual

Plate 3.19-6



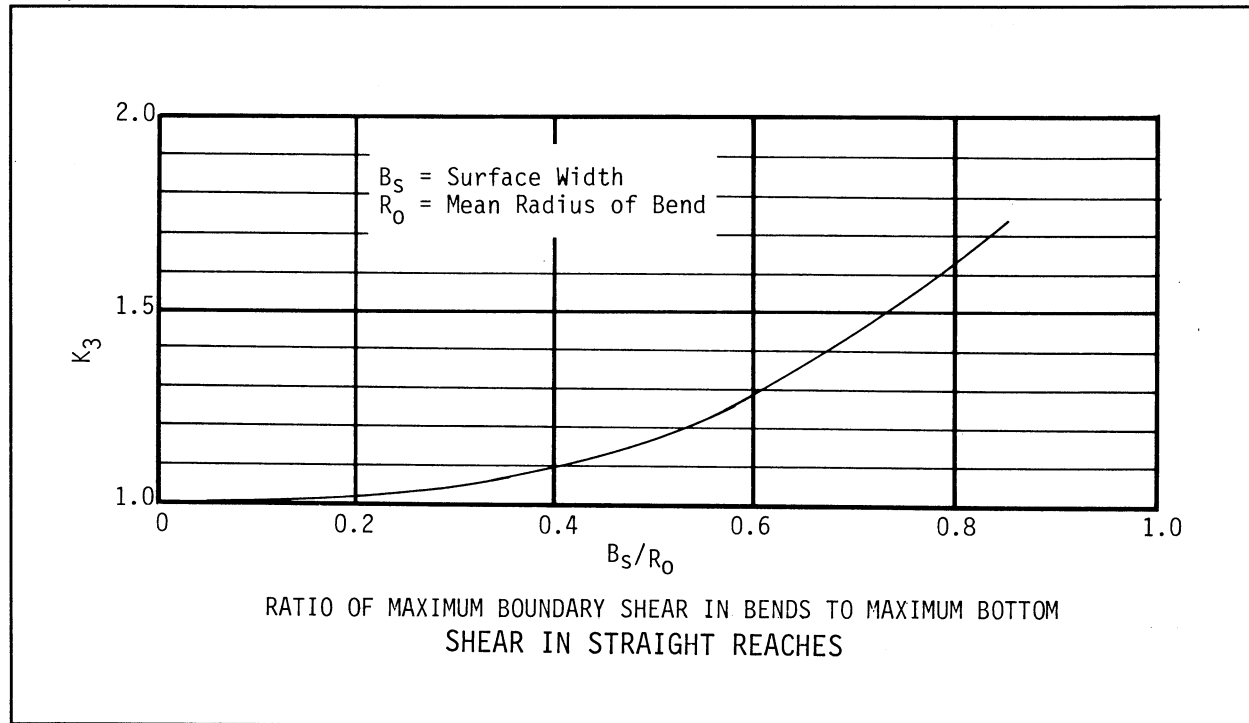
Source: VDOT Drainage Manual

Plate 3.19-7

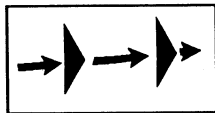
## APPENDIX 3.19-b

**RIPRAP DESIGN EQUATIONS FOR LAKES  
AND PONDS SUBJECT TO WAVE ACTION**

In many instances, riprap is installed along the shoreline of nontidal ponds and lakes in order to protect them from the continual scour of wind-driven waves. The following methods/equations will produce minimum design parameters for size of stone, depth of buried toe (or width of riprap apron) and height of structure above average water level.

- I. **Size of Riprap Required** - See VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action").
- II. **DWH (Design Wave Height)** - See VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action") or U.S. Army Corps of Engineers' Shore Protection Manual.
- III. **Depth of Buried Toe** = DWH at design wind speed.
- IV. **Width of Riprap Apron (Alternative to Buried Toe)** =  $DWH \times 2$
- V. **Height of Structure (Above the Average Water Level)** =  $DWH \times 1.5$

## STD &amp; SPEC 3.20



## ROCK CHECK DAMS

Definition

Small temporary stone dams constructed across a swale or drainage ditch.

Purpose

To reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps sediment generated from adjacent areas or the ditch itself, mainly by ponding of the stormwater runoff. Field experience has shown it to perform more effectively than silt fence or straw bales in the effort to stabilize "wet-weather" ditches.

Conditions Where Practice Applies

This practice, utilizing a combination of stone sizes, is limited to use in small open channels which drain 10 acres or less. It should not be used in a live stream as the objective should be to protect the live watercourse. Some specific applications include:



1. Temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining but still need protection to reduce erosion.
2. Permanent ditches or swales which, for some reason, cannot receive a permanent non-erodible lining for an extended period of time.
3. Either temporary or permanent ditches or swales which need protection during the establishment of grass linings.
4. An aid in the sediment trapping strategy for a construction site. This practice is not a substitute for major perimeter trapping measures such as a SEDIMENT TRAP (Std. & Spec. 3.13) or a SEDIMENT BASIN (Std. & Spec. 3.14).

### Planning Considerations

Check dams are effective in reducing flow velocity and thereby the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install a structural channel lining than to install check dams. However, under circumstances where this is not feasible, check dams are useful.

Check dams installed in grass-lined channels may kill the vegetative lining if submergence after rains is too long and/or silting is excessive.

If check dams are used in grass-lined channels which will be mowed, care should be taken to remove all the stone when the dam is removed. This should include any stone which has washed downstream.

As previously mentioned, they have been found to be an effective aid in trapping sediment particles by virtue of their ability to pond runoff.

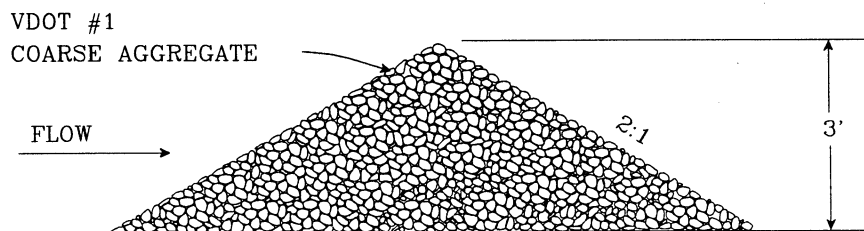
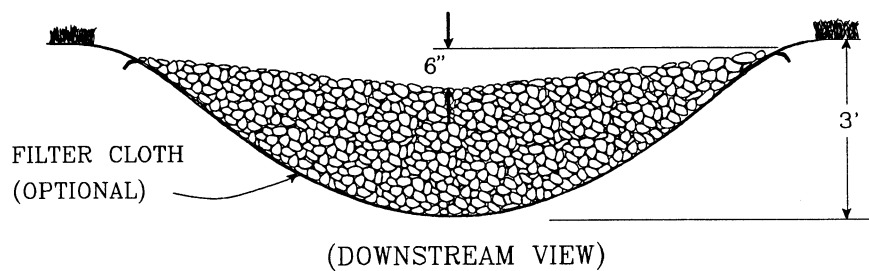
### Specifications

No formal design is required for a check dam, however the following criteria should be adhered to when specifying check dams:

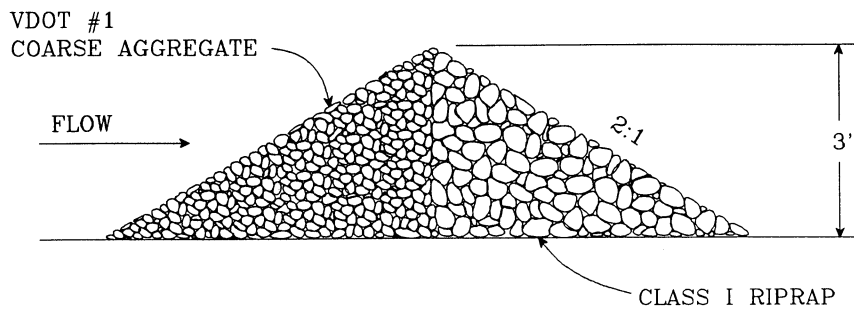
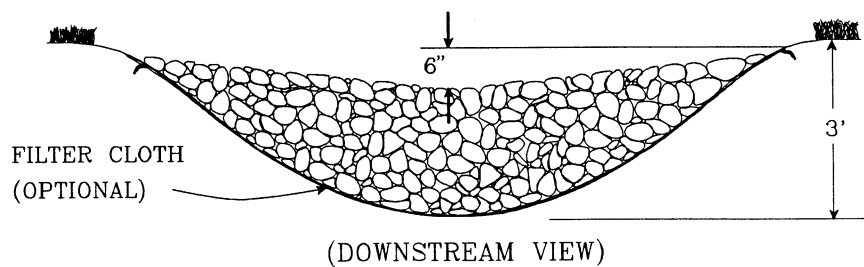
1. The drainage area of the ditch or swale being protected shall not exceed 2 acres when VDOT #1 Coarse Aggregate is used alone and shall not exceed 10 acres when a combination of Class I Riprap (added for stability) and VDOT #1 Coarse Aggregate is used. Refer to Plate 3.20-1 for orientation of stone and a cross-sectional view of the measure. An effort should be made to extend the stone to the top of channel banks.
2. However, the maximum height of the dam shall be 3.0 feet.

# ROCK CHECK DAM

2 ACRES OR LESS OF DRAINAGE AREA:



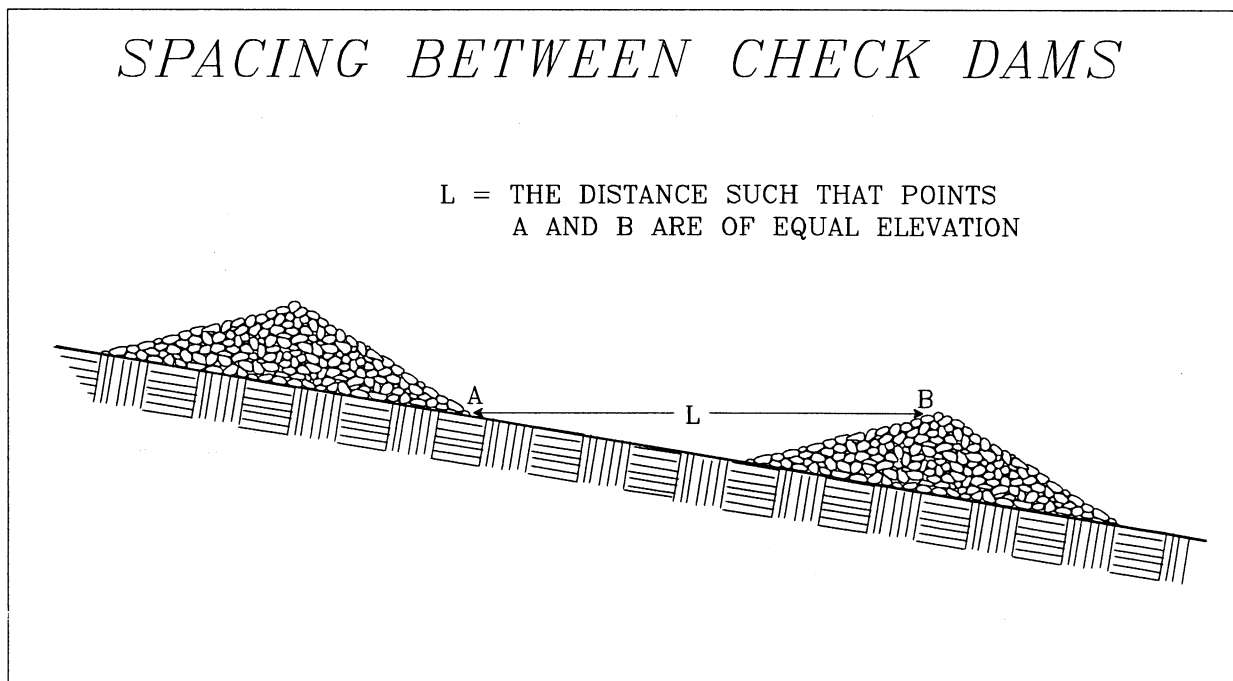
2-10 ACRES OF DRAINAGE AREA:



3. The center of the check dam must be at least 6 inches lower than the outer edges. Field experience has shown that many dams are not constructed to promote this "weir" effect. Stormwater flows are then forced to the stone-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function.
4. For added stability, the base of the check dam can be keyed into the soil approximately 6 inches.
5. The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam (see Plate 3.20-2).
6. Stone should be placed according to the configuration in Plate 3.20-1. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.
7. Filter cloth may be used under the stone to provide a stable foundation and to facilitate the removal of the stone. See Std. and Spec. 3.19, RIPRAP, for required physical properties of the filter cloth.

#### Sediment Removal

Sediment should be removed from behind the check dams when it has accumulated to one half of the original height of the dam.



Source: Va. DSWC

Plate 3.20-2

### Removal of Practice

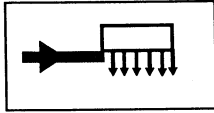
Unless they will be incorporated into a permanent stormwater management control, check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when they are no longer needed. In permanent structures, check dams should be removed when a permanent lining can be installed. In the case of grass-lined ditches, check dams should be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after they are removed. The use of filter cloth underneath the stone will make the removal of the stone easier.

### Maintenance

Check dams should be checked for sediment accumulation after each runoff-producing storm event. Sediment should be removed when it reaches one half of the original height of the measure.

Regular inspections should be made to insure that the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

## STD &amp; SPEC 3.21



## LEVEL SPREADER

Definition

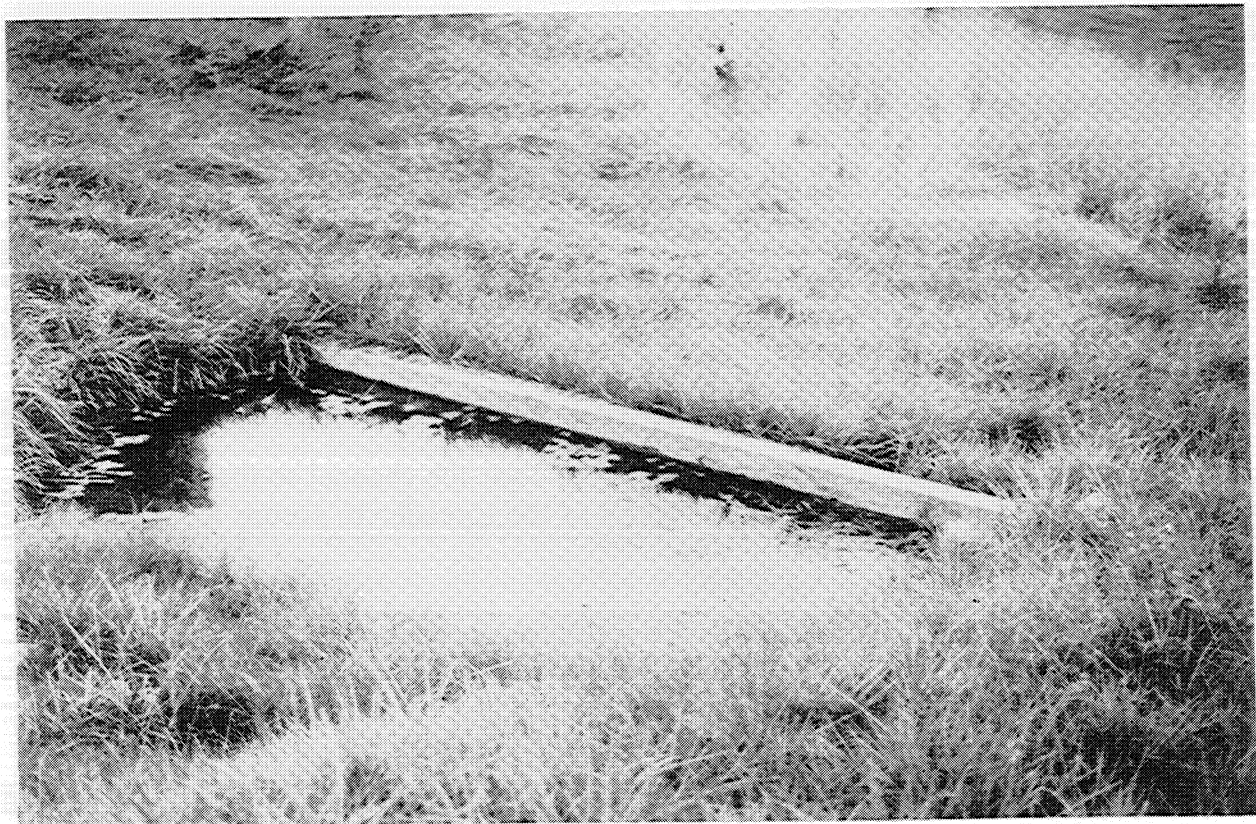
An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose

To convert concentrated runoff to sheet flow and release it uniformly onto areas stabilized by existing vegetation.

Conditions Where Practice Applies

Where there is a need to divert stormwater away from disturbed areas to avoid overstressing erosion control measures; where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion.





This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is uniform with a slope of 10% or less and is stabilized by natural vegetation. The runoff water should not be allowed to reconcentrate after release unless it occurs during interception by another measure (such as a permanent pond or detention basin) located below the level spreader.

### Planning Considerations

The TEMPORARY DIVERSION DIKE, (Std.& Spec. 3.09) and the TEMPORARY RIGHT-OF-WAY DIVERSION, (Std. & Spec. 3.11) each call for a stable outlet for concentrated stormwater flows. The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable (see Plate 3.21-1).

The outlet area must be uniform and well-vegetated with slopes 10% or less. Particular care must be taken to construct the outlet lip completely level in a stable, undisturbed soil. Any depressions in the lip will concentrate the flow, resulting in erosion. Under higher design flow conditions, a rigid outlet lip design should be used to create the desired sheet flow conditions. Runoff water containing high sediment loads must be treated in a sediment trapping device before being released to a level spreader.

### Design Criteria

No formal design is required. The following criteria must be met:

#### Spreader Dimensions

Determine the capacity of the spreader by estimating the peak flow expected from a 10-year storm ( $Q_{10}$ ).

Select the appropriate length, width and depth of the spreader from Table 3.21-A.

For design flows greater than 20 cfs, the measure should be designed by a qualified engineer.

A 20-foot transition section should be formed in the diversion channel so that the width of the diversion will smoothly tie in with the width of the spreader to ensure more uniform outflow.

The depth of the level spreader, as measured from the lip, shall be at least 6 inches. The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

TABLE 3.21-A

## MINIMUM DIMENSIONS FOR LEVEL SPREADER

<u>Design Flow,</u> <u>Q<sub>10</sub> (cfs)</u>	<u>Depth</u> <u>(ft.)</u>	<u>Width of Lower</u> <u>Side Slope of</u> <u>Spreader (ft.)</u>	<u>Length</u> <u>(ft.)</u>
0-10	0.5	6	10
10-20	0.6	6	20

Source: Va. DSWC

Grade

1. The grade of the channel for the last 20 feet of the dike or diversion entering the level spreader shall be less than or equal to 1% (see Plate 3.21-1).
2. The grade of the level spreader channel shall be 0%.

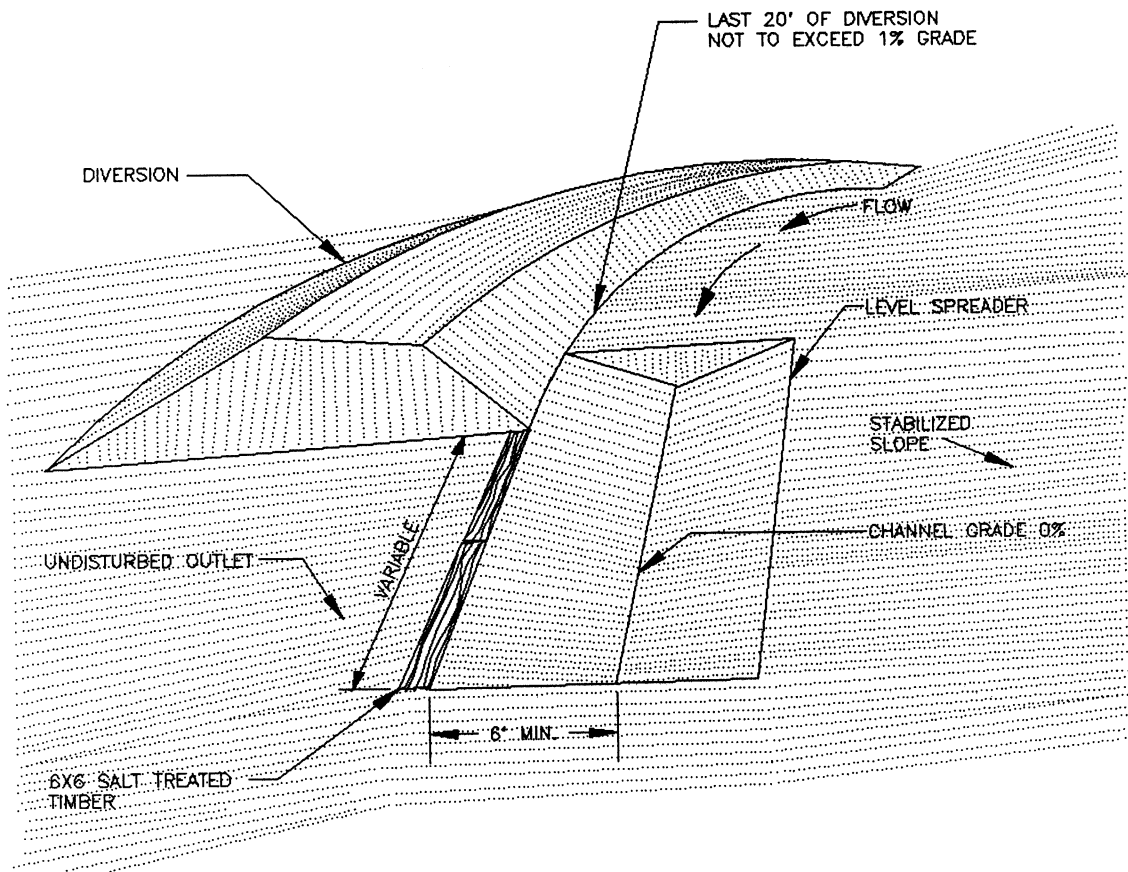
Spreader Lip

The release of the stormwater will be over the level lip onto an undisturbed well-vegetated area with a maximum slope of 10%. The level lip should be of uniform height and zero grade over the length of the spreader.

The level spreader lip may be stabilized by vegetation or may be of a rigid non-erodible material depending on the expected design flow:

<u>Spreader Lip</u>	<u>Design Flow</u> <u>(cfs)</u>
Vegetated	0 - 4
Rigid	5 - 20

# LEVEL SPREADER



## PERSPECTIVE VIEW

NOTE: ALL TEMPORARY BERMS, SWALES AND LEVEL SPREADER DITCH MUST RECEIVE TEMPORARY SEEDING IMMEDIATELY AFTER INSTALLATION

Source: Adapted from N.C. Erosion and Sediment Control Planning and Design Manual

Plate 3.21-1

A vegetated level lip must be constructed with an erosion-resistant material, such as jute or excelsior blankets, to inhibit erosion and allow vegetation to become established (see Plate 3.21-2).

For higher design flows and permanent installations, a rigid lip of non-erodible material, such as pressure-treated timbers or concrete curbing, should be used (see Plate 3.21-2).

#### Construction Specifications

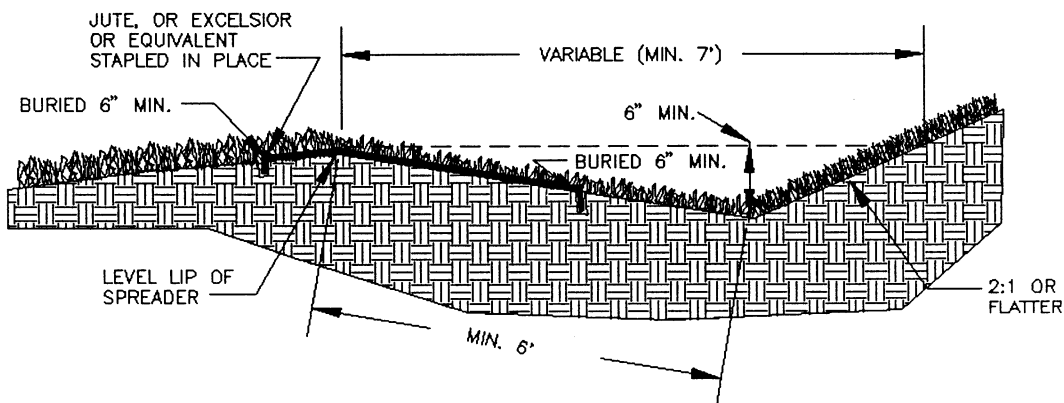
1. Level spreaders must be constructed on undisturbed soil (not fill material).
2. The entrance to the spreader must be shaped in such a manner as to insure that runoff enters directly onto the 0% channel.
3. Construct a 20-ft. transition section from the diversion channel to blend smoothly to the width and depth of the spreader.
4. The level lip shall be constructed at 0% grade to insure uniform spreading of stormwater runoff.
5. Protective covering for vegetated lip should be a minimum of 4 feet wide extending 6 inches over the lip and buried 6 inches deep in a vertical trench on the lower edge. The upper edge should butt against smoothly cut sod and be securely held in place with closely spaced heavy duty wire staples (see Plate 3.21-2).
6. Rigid level lip should be entrenched at least 2 inches below existing ground and securely anchored to prevent displacement. An apron of VDOT #1, #2 or #3 Coarse Aggregate should be placed to top of level lip and extended downslope at least 3 feet. Place filter fabric under stone and use galvanized wire mesh to hold stone securely in place (see Plate 3.21-2).
7. The released runoff must outlet onto undisturbed stabilized areas with slope not exceeding 10%. Slope must be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.
8. Immediately after its construction, appropriately seed and mulch the entire disturbed area of the spreader.

#### Maintenance

The measure shall be inspected after every rainfall and repairs made, if required. Level spreader lip must remain at 0% slope to allow proper function of measure. The contractor should avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, it shall be repaired immediately.

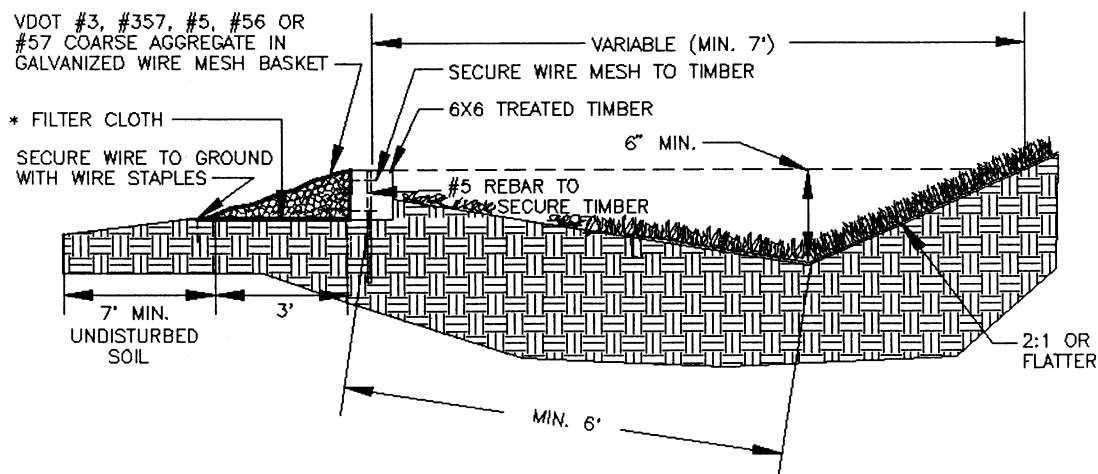
# LEVEL SPREADER

## CROSS SECTION



## LEVEL SPREADER WITH VEGETATED LIP

## CROSS SECTION



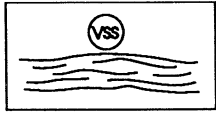
## LEVEL SPREADER WITH RIGID LIP

\* MIN. PHYSICAL REQUIREMENTS OF FILTER CLOTH NOTED IN STD. & SPEC. 3.19, RIPRAP

Source: Va. DSWC and N.C. Erosion and Sediment Control Planning and Design Manual

Plate 3.21-2

## STD &amp; SPEC 3.22

VEGETATIVE STREAMBANK  
STABILIZATIONDefinition

The use of vegetation in stabilizing streambanks.

Purpose

To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Along banks in creeks, streams and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 5 ft./sec. and soils are erosion resistant. Above 5 ft./sec., structural measures are generally required. This practice does not apply where tidal conditions exist.



### Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bank-full flows which often result from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 1½ to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels are subject to a 3- to 5-fold increase in the frequency of bank-full flows. As a result, stream channels that were once parabolic in shape and covered with vegetation are often transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, if employed correctly, immediately insure a satisfactory protection of the banks. However, many such structures are expensive to build and to maintain and frequently cause downstream velocity problems. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the re-establishment of native plants and animals, especially when the design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective where the cover consists of natural plant communities which are native to the site. Planting vegetation is less damaging to the environment than installing structures. Vegetation also provides habitat for fish and wildlife and is aesthetically pleasing. Plants provide erosion protection to streambanks by reducing stream velocity, binding soil in place with a root mat and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first.

One disadvantage of vegetation is that it lowers the carrying capacity of the channel, which may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The erosion potential for the stream needs to be evaluated to determine the best solutions. The following items should be considered in the evaluation:

1. The frequency of bankfull flow based on anticipated watershed development.
2. The channel slope and flow velocity, by design reaches.
3. The antecedent soil conditions.
4. Present and anticipated channel roughness ("n") values.
5. The location of channel bends along with bank conditions.

6. The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks and sharp bends may require structural stabilization measures such as riprap, while the remainder of the streambank may require only vegetation.

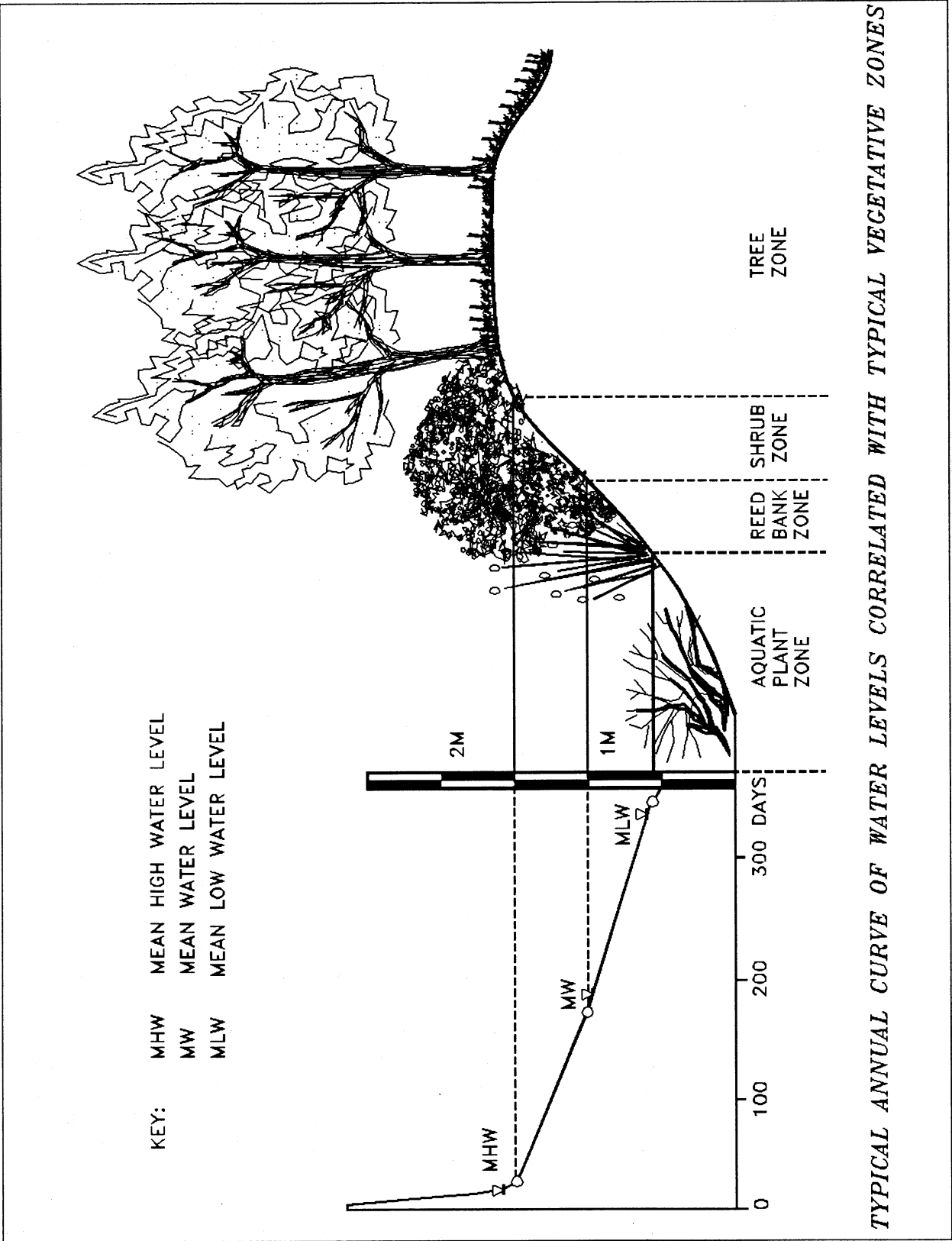
Where streambank stabilization is required and velocities appear too high for the use of vegetation, one should consider structural measures (see Std. & Spec. 3.23, STRUCTURAL STREAMBANK STABILIZATION) or the use of permanent erosion control matting (see Std. & Spec. 3.36, SOIL STABILIZATION MATTING). Notably, any applicable approval or permits from other state or federal agencies must be obtained prior to working in such areas.

### Vegetation Zones Along Watercourses

At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which are dependent upon site conditions such as the steepness and shape of the bank and the seasonal and local variations in water depth and flow rate. Streambanks commonly exhibit the following zonation (see Plate 3.22-1):

1. Aquatic Plant Zone - This zone is normally permanently submerged. In Virginia, this zone is inhabited by plants such as pondweeds and water lilies, which reduce the water's flow rate by friction. The roots of these plants help to bind the soil, and they further protect the channel from erosion because the water flow tends to flatten them against the banks and bed of the stream.
2. Reed-Bank Zone - The lower part of this zone is normally submerged for only about half the year. In Virginia, this zone is inhabited by rushes, reed grasses, cattails, and other plants which bind the soil with their roots, rhizomes and shoots and slow the water's flow rate by friction.
3. Shrub Zone - This zone is flooded only during periods of average high water. In Virginia, the shrub zone is inhabited by trees and shrubs--such as willow, alder, dogwood and viburnum--with a high regenerative capacity. These plants hold the soil with their root systems and slow water speed by friction. They also protect tree trunks from damage caused by breaking ice and help to prevent the formation of strong eddies around large trees during flood flows. Shrub zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. Infringement of shrub vegetation into the channel tends to reduce the channel width, increasing probability of floods. However, brief flooding of riverside woods and undeveloped bottomlands does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.
4. Tree Zone - This zone is flooded only during periods of very high water (i.e., the 2-year bank-full flow or greater flows). Typical plants in Virginia are trees in the ash-elm, alder-ash, and oak-horn-beam associations. These trees hold soil in place with their root systems.





Source: Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-1

### Design Criteria

Table 3.22-A provides general guidelines for maximum allowable velocities in streams to be protected by vegetation.

1. Ensure that channel bottoms are stable before stabilizing channel banks.
2. Keep velocities at bankfull flow non-erosive for the site conditions.
3. Provide mechanical protection such as rip-rap on the outside of channel bends if bankfull stream velocities approach the maximum allowable for site conditions.
4. Be sure that requirements of other state or federal agencies are met in the design in the case that other approvals or permits are necessary.

<p style="text-align: center;"><b>TABLE 3.22-A</b></p> <p style="text-align: center;"><b>CONDITIONS WHERE VEGETATIVE STREAMBANK STABILIZATION IS ACCEPTABLE</b></p>		
<u>Frequency of Bankfull Flow</u>	<u>Max. Allowable Velocity for Highly Erodible Soil</u>	<u>Maximum Allowable Velocity (Erosion Resistant Soil)</u>
> 4 times/yr.	4 ft./sec.	5 ft./sec.
1 to 4 times/yr.	5 ft./sec.	6 ft./sec.
< 1 time/yr.	6 ft./sec.	6 ft./sec.

Source: Va. DSWC

### Planting Guidelines

Guidelines will be presented only for the reed-bank and shrub zones. The aquatic plant zone is difficult to implant and establish naturally when reed-bank vegetation is present. There are presently many experts in this field at the federal, state, and private sector levels who can be consulted concerning successful establishment of plants in the aquatic zone. The tree zone is least significant in terms of protecting banks from more frequent erosion-force flows, since this zone is seldom flooded. Also, shade from trees in this zone can prevent adequate establishment of vegetation in other zones.

# 1. Establishing Reed-Bank Vegetation

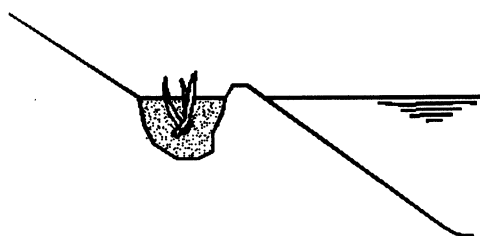
There are various ways of planting reed-bank vegetation. The following plants are considered suitable:

Common Reed	( <i>Phragmites communis</i> )
Reed Canary Grass	( <i>Phalaris arundinaceae</i> )
Great Bulrush	( <i>Scirpus lacustris</i> )
Common Cattail	( <i>Typha latifolia</i> )

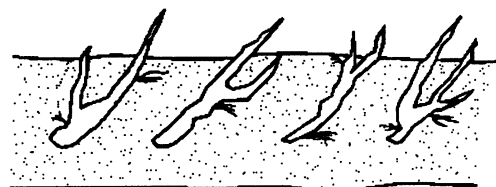
The greatest protection seems to be provided by the Common Reed. It is a very robust plant whose stems become woody in the autumn, resulting in continued protection during the winter. Because the shoots and rhizomes are deeply and strongly rooted and densely intertwined, they bind the soil more firmly than any other reed. The stems and roots have dormant buds at the nodes and are capable of sprouting when planted. However, the Common Reed does grow high and thick, and periodic maintenance may be needed in order to achieve a neat appearance.

- a. Planting in Clumps: The oldest and most common method of planting reeds is planting in clumps (see Plate 3.22-2 (a)). The stems of the reed colony are scythed. Then square clumps are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds of their height.
- b. Planting Rhizomes and Shoots: Less material is needed for the planting of rhizomes and shoots, a procedure which can be used to establish the Common Reed, Reed Grass, Bulrush, Cattail and other plants. Slips are taken from existing beds during the dormant season, after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or the tips of the sprouts. They are placed in holes or narrow trenches, along the line of the average summer water level, so that only the stem sprouts are showing above the soil.
- c. Planting Stem Slips: It is possible to plant stem slips of the Common Reed along slow-moving streams (see Plate 3.22-2 (b)). Usually, three slips are set in a pit 12 to 20 inches deep. If the soil is packed or strong, the holes must be made with a dibble bar or some other metal planting tool. The pits should be located approximately 1 foot apart.
- d. Reed Rolls: In many cases, the previously described methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have therefore been designed, in which protection of the bank is at first insured by structural materials. Along slow to fairly fast

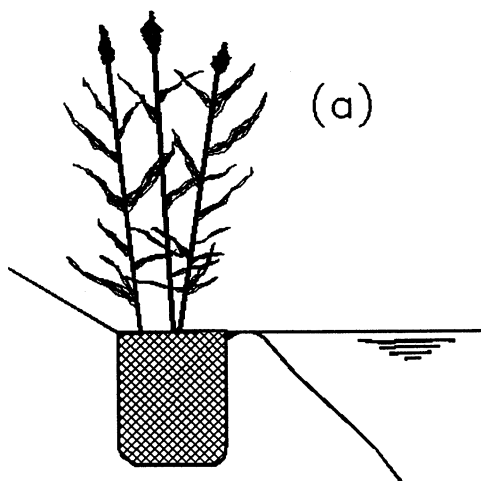
## *METHODS OF ESTABLISHING REED BANK VEGETATION*



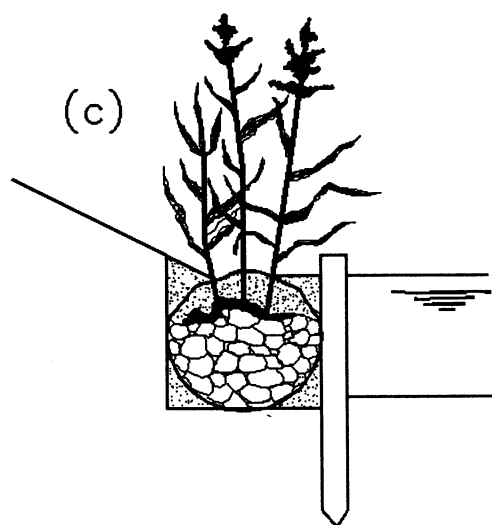
(b)



PLANTING STEM SLIPS



(a)



(c)

PLANTING CLUMPS

REED ROLLS

Source: Importance of Natural Vegetation for the Protection  
of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-2

streams, the most effective method of establishing reed-bank vegetation has been found to be the use of Reed Rolls (see Plate 3.22-2 (c)). A trench 18 inches wide and deep is dug behind a row of stakes. Wire netting, such as  $\frac{1}{2}$ -inch hardware cloth, is then stretched from both sides of the trench between upright planks. Onto this netting is dumped fill material such as coarse gravel, sod, or soil and other organic material. This material is then covered by reed clumps until the two edges of the wire netting can just be held together with wire. The upper edge of the roll should be no more than 2 inches above the level of the water. Finally, the planks are taken out, and any gaps along the sides of the roll are filled in with earth. This method provides greater protection from the possibility of a heavy flow washing away the vegetative materials before they have a chance to become established.

- e. Seeding: Reed Canary Grass can be sown 1/2-inch deep on very damp bank soil, provided that the seeded surface is not covered by water for six months after sowing. Seed at a rate of 12-15 lbs./acre. Reed Canary Grass is a cool season grass and should not be seeded in the summer.
  - f. Vegetation and Stone Facing: Reed-bank and other types of vegetation can be planted in conjunction with rip-rap or other stone facing by planting clumps, rhizomes or shoots in the crevices and gaps along the line of the average summer water level.
2. Establishing Shrub Zone Vegetation: Stands of full-grown trees are of little use for protecting streambanks apart from the binding of soil with their roots. Shrubwood provides much better protection; and in fact, riverside stands of willow trees are often replaced naturally by colonies of shrub-like willows. Plants should be used which can easily adapt to the stream and site conditions.
- a. Seeding and Sodding: Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used alone to stabilize the streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 4 inches in diameter should be retained whenever possible. Topsoil should be conserved for re-use. Seeding mixtures should be selected and operations performed according to Std. & Spec. 3.32, PERMANENT SEEDING. Some type of erosion control blanket, such as jute netting, excelsior blankets, or equivalent should be installed according to Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING. Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to Std. & Spec. 3.33, SODDING. Turf should only be used where the grass will provide adequate protection, necessary maintenance can be provided, and establishment of other streambank vegetation is not practical or possible.

- b. Planting Cuttings and Seedlings: Shrub willows, shrub dogwoods and alders can be put into the soil as cuttings, slips or stems. In dense shade, shrubs such as the Blue Arctic Willow (*Salix purpurea nana*) and the Silky Dogwood (*Cornus amomum*) or evergreen ground covers such as Lily Turf (*Liriope Muscari*) or Hall's Honeysuckle (*Linicera hallsiana*) are appropriate. The Silky Dogwood also works well in sunny areas. On larger streams, "Streamco" Purpleosier Willow (*Salix purpurea* "Streamco") and Bankers' Dwarf Willow (*Salix x Cotteti*) have been widely used with success. Two native river alders (*Alnus serrulata* and *Alnus rugosa*), which occur throughout the northeast, also show great promise for streambank stabilization, although they have not been fully tested. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope of 2:1 (3:1 preferred), removing overhanging bank edges.

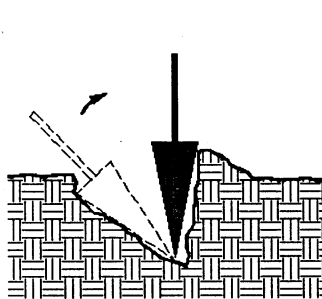
Willows can be planted as 1-year old, nursery-grown, rooted cuttings or as fresh hardwood cuttings gathered from local mother-stock plantings. Silky Dogwood and the alders should be nursery-grown seedlings 1 or 2 years old. Fresh cuttings should be 3/8- to 1/2-inch thick and 12 to 18 inches long. They should be kept moist. If not used at once, they should be stored in cool moist sand.

Streambanks are often difficult to plant, even when they are well-sloped. This is especially true in gravelly or strong banks. Where mattocks or shovels are unsatisfactory tools, a stiff steel bar, such as a crowbar, is better. The best tool for this purpose is a dibble bar, a heavy metal tool with a blade and a foot pedal. It is thrust into the ground to make a hole for the plant (see Plate 3.22-3).

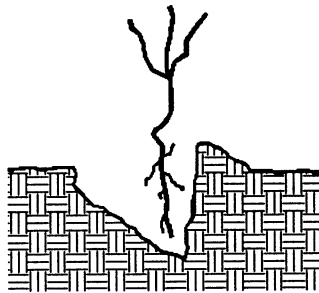
Rooted cuttings should be planted vertically in the bank with 1 or 2 inches of wood protruding above the ground surface. They should be stuck in a hole large enough to accommodate the root system when well spread. The plant roots must be maneuvered into the bottom of the hole so they will grow down instead of up. The roots should not be twisted, nor should they be exposed above the ground surface. After the plant is placed, the dibble bar can be installed a few inches away from the plant to close the hole. Slow-release fertilizer should be applied on the surface, not in the hole. The soil should be tamped adequately to provide complete contact between the soil and the cutting. Cuttings should be planted 1 foot on center in at least 3 rows located at the top, middle and bottom of the shrub zone.

Plant seedlings of the river alders vertically in the bank to the depth they were growing in the nursery. Use the same procedure described previously. Plant one row of alders at 2-foot intervals at the base of the shrub zone, not more than 1.5 to 3 feet from the average summer water level or from the reeds. A greater distance is of no use unless a belt of tall perennial herb colonies is established between the reeds and the alders. Plant the next row 2 feet up

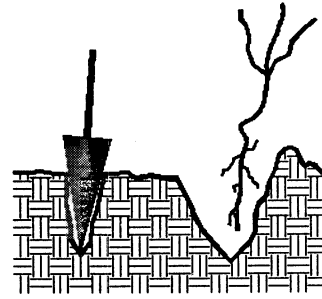
## DIBBLE PLANTING



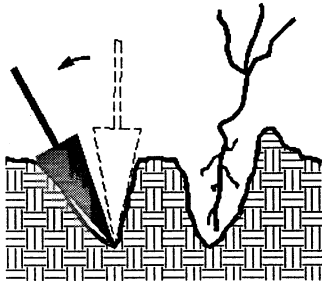
1. INSERT DIBBLE AT ANGLE AND PUSH FORWARD TO UPRIGHT POSITION.



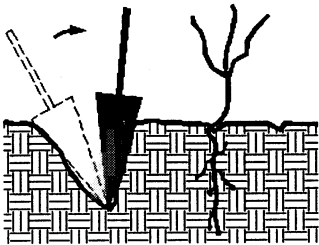
2. REMOVE DIBBLE AND PLACE SEEDLING AT CORRECT DEPTH.



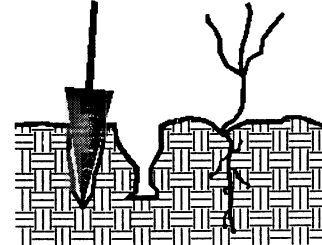
3. INSERT DIBBLE 2 INCHES TOWARD PLANTER FROM SEEDLING.



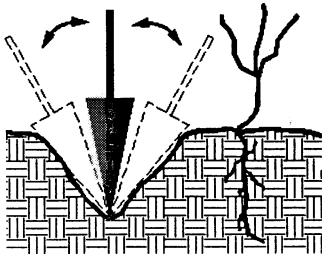
4. PULL HANDLE OF DIBBLE TOWARD PLANTER FIRING SOIL AT BOTTOM OF ROOTS.



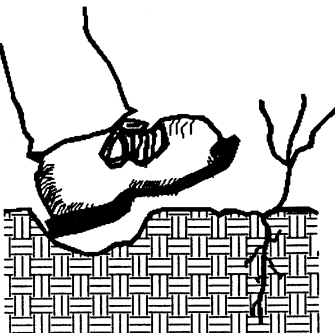
5. PUSH HANDLE OF DIBBLE FORWARD FROM PLANTER FIRING SOIL AT TOP OF ROOTS.



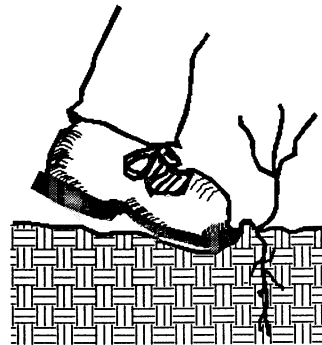
6. INSERT DIBBLE 2 INCHES FROM LAST HOLE.



7. PUSH FORWARD THEN PULL BACKWARD FILLING HOLE.



8. FILL IN LAST HOLE BY STAMPING WITH HEEL.



9. FIRM SOIL AROUND SEEDING WITH FEET.

Source: A Guide For Vegetating Surface-Mined Lands For Wildlife in Eastern Kentucky and West Virginia, USDI-Fish and Wildlife Service

Plate 3.22-3

the slope, with a third row 4 feet up the slope. Plant at least 3 rows. Locate the plants in a diamond pattern.

Since these plants are generally not effective for the first two years, grasses can be seeded immediately following their planting to provide initial streambank protection. The seed mixtures noted in Table 3.22-B are appropriate plantings.

**TABLE 3.22-B**

**INITIAL STREAMBANK PLANTINGS: SEED MIXTURES BY REGION\***

Appalachian Region	Piedmont Region	Coastal Plain
Kentucky-31 Tall Fescue: 65 lbs./acre  Creeping Red Fescue: 15 lbs./acre  Redtop Grass: 5 lbs./acre	Kentucky-31 Tall Fescue: 80 lbs./acre.  Redtop Grass: 5 lbs./acre	Kentucky-31 Tall Fescue: 65 lbs./acre  Bermudagrass: 15 lbs./acre  Redtop Grass: 5 lbs./acre
* Physiographic Regions are described in Std. & Spec. 3.32, PERMANENT SEEDING.		

Source: Va. DSWC

The seedbed should be roughened with rakes and fertilized with 500 to 1000 pounds per acre of 10-10-10, adjusted to meet the needs of the site. Special care should be used when fertilizing next to water sources to avoid any unnecessary introduction of nitrogen/phosphorus into the water. Seed should be broadcast, covered lightly and mulched with 2 tons of straw per acre (2-3 bales per 1000 square feet) or a minimum of 1500 pounds of wood fiber mulch per acre (2000 pounds per acre preferred). If straw is used, it should be properly anchored with netting or an effective tackifier. Erosion control blankets/mats are often very effective aids in the establishment of grasses or

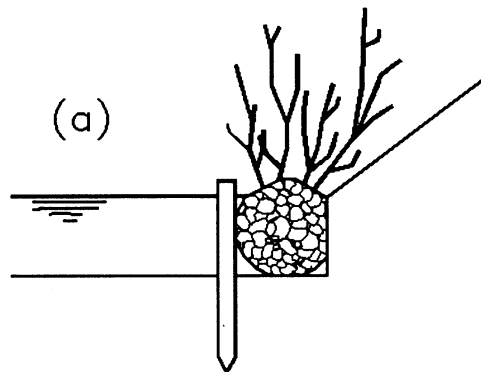


plant material along streambanks (see Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING).

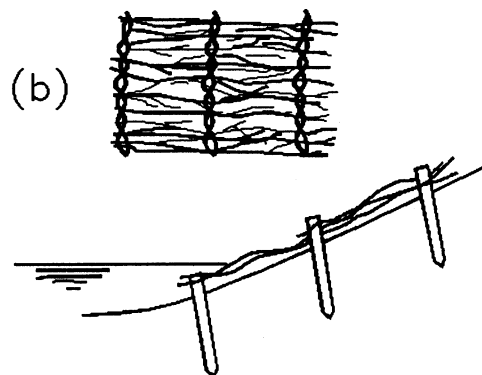
Willows and other softwoods can also be bound together in various ways in order to insure immediate protection of the streambank.

- c. Fascine Rolls: Fascine rolls are bundles of brushwood and sticks, without branches if possible, that are filled with coarse gravel and rubble and wired tightly around the outside. They are 4 to 20 yards long and 4 to 16 inches in diameter. They are set against the bank so that the parts which are to take root touch the ground above the water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and retards the loss of moisture from the wood (see Plate 3.22-4 (a)).
- d. Willow Mattresses: The degree of streambank protection can be increased by using willow mattresses or packed fascine work. Willow mattresses consist of 4- to 8-inch thick layers of growing branches set perpendicular to the direction of the current or sloping downstream, with the broad ends of the branches oriented downwards. The branches are held together with interweaving wire or other branches at intervals of 24 to 32 inches, set parallel to the direction of the current or at an angle of 30 degrees. If several layers of mattress are necessary, the tops of the lower layers should cover the bases of the upper layers. The bottom layer is fixed at the base in a trench previously dug at the base of the softwood zone. The whole mattress structure should be covered with 2 to 10 inches of earth or fine gravel (Plate 3.22-4 (b)).
- e. Packed Fascine-Work: Packed fascine-work [Plate 3.22-4 (c)] consists essentially of layers of branches laid one across the other to a depth of 8 to 12 inches and covered with fascine rolls. The spaces between the fascine rolls are filled with gravel, stones and soil so that no gaps remain; and a layer of soil and gravel 8 to 12 inches thick is added on top. Packed fascine-work is particularly suitable for repairing large breaches in the banks of streams with high water levels.
- f. Combination with Stone Facing: In many places, the bank is not adequately protected by vegetation until the roots are fully developed, and temporary protection must be provided by inanimate materials. There is a wide choice of methods, including the planting of woody plants in the crevices of stone facing (Plate 3.22-4 (d)). For structural protection measures, see Std. & Spec. 3.23, STRUCTURAL STREAMBANK PROTECTION.

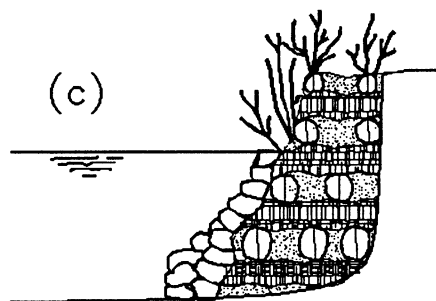
## *METHODS OF ESTABLISHING SHRUB ZONE VEGETATION*



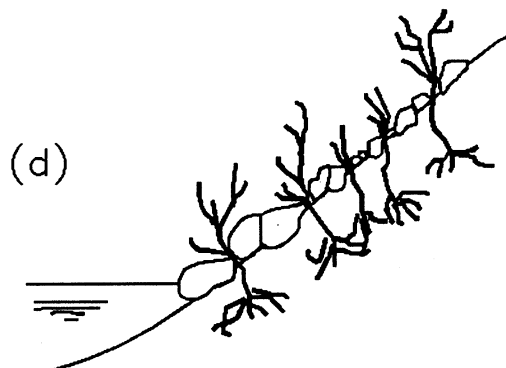
FASCINE ROLL



WILLOW MATTRESS



PACKED FASCINE WORK



CUTTINGS  
BETWEEN RIPRAP

Source: Importance of Natural Vegetation for the Protection  
of the Banks of Streams, Rivers and Canals, Seibert

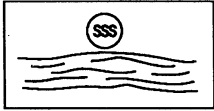
Plate 3.22-4

### Maintenance

Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants, and mulched if necessary. Fresh cuttings from other plants on the bank can be used, or they can be taken from mother-stock plantings if they are available. Trees that become established on the bank should be removed at once.

## STD &amp; SPEC 3.23

# STRUCTURAL STREAMBANK STABILIZATION



## Definition

Methods of stabilizing the banks of live streams with permanent structural measures.

## Purpose

To protect streambanks from the erosive forces of flowing water.

## Conditions Where Practice Applies

Applicable to streambank sections which are subject to excessive erosion due to increased flows or disturbance during construction. Generally applicable where flow velocities exceed 5 ft./sec. or where vegetative streambank protection is inappropriate.



### Planning Considerations

Stream channel erosion problems vary widely in type and scale and there are many different structural stabilization techniques which have been employed with varying degrees of effectiveness. The purpose of this specification is merely to point out some of the practices which are available and to establish some broad guidelines for their selection and design. Such structures should be planned and designed in advance by an engineer or some other qualified individual with appropriate experience. Many of the practices referenced here involve the use of manufactured products and should be designed and installed in accordance with the manufacturers' specifications.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization (Std. & Spec. 3.22) alone or in conjunction with structural measures, to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics.

### General Guidelines

Since each reach of channel requiring protection is unique, measures for streambank protection should be installed according to a plan and adapted to the specific site. Designs should be developed according to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.
2. The bottom scour should be controlled, by either natural or artificial means, before any permanent type of bank protection can be considered feasible. This is not necessary if the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.
3. Streambank protection should be started and ended at a stabilized or controlled point on the stream.
4. Changes in channel alignment shall be made only after an evaluation of the effect upon land use, interdependent waste water systems, hydraulic characteristics and existing structures.
5. Special attention should be given to maintaining and improving habitat for fish and wildlife.
6. The design velocity should be that of the peak discharge of the 10-year storm. Structural measures must be effective for this design flow and must be capable of withstanding greater flows without serious damage.

7. All requirements of state law and permit requirements of local, state and federal agencies must be met.
8. Stabilize all areas disturbed by construction as soon as the structural measures are complete.

### Streambank Protection Measures

Riprap - heavy angular stone placed (preferably) or dumped onto the streambank to provide armor protection against erosion. Riprap shall be designed and installed according to the practice entitled RIPRAP (Std. & Spec. 3.19).

Gabions - rectangular, rock-filled wire baskets are pervious, semi-flexible building blocks which can be used to armor the bed and/or banks of channels or to divert flow away from eroding channel sections. Gabions should be designed and installed in accordance with manufacturer's standards and specifications (see Plate 3.23-1). At a minimum, they should be constructed of a hexagonal triple twist mesh of heavily galvanized steel wire (galvanized wire may also receive a poly-vinyl chloride coating). The design water velocity for channels utilizing gabions should not exceed that given below:

<u>Gabion Thickness</u> <u>(feet)</u>	<u>Maximum Velocity</u> <u>(feet per second)</u>
1/2	6
3/4	11
1	14

Deflectors (groins or jetties) - Structural barriers which project into the stream to divert flow away from eroding streambank sections. Plate 3.23-2 contains general guidelines for designing and installing deflectors.

### Installation of Structures Under Wave and/or Tidal Action

The installation of riprap, gabions or deflectors under significant wave action or under tidal conditions requires special design considerations to ensure stability of the measure and the area it protects. The design/installation of these measures for tidal areas is beyond the scope of the Virginia Erosion and Sediment Control Law and Virginia Erosion and Sediment Control Regulations. The DSWC's Shoreline Programs Bureau can be consulted in regard to minimum design parameters for tidal installations. For situations where there

is significant wave action affecting the shoreline of a nontidal lake or pond, the design parameters presented in Std. & Spec. 3.19, RIPRAP, should be used. Notably, there are many other site specific factors which should be incorporated into a design; hence, it is recommended that the design parameters presented only be used as minimum requirements and that a qualified professional be consulted when the installation of such a structure is contemplated.

Reinforced Concrete - may be used to armor eroding sections of the streambank by constructing retaining walls or bulk heads. Positive drainage behind these structures must be provided. Reinforced concrete may also be used as a channel lining (see Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL).

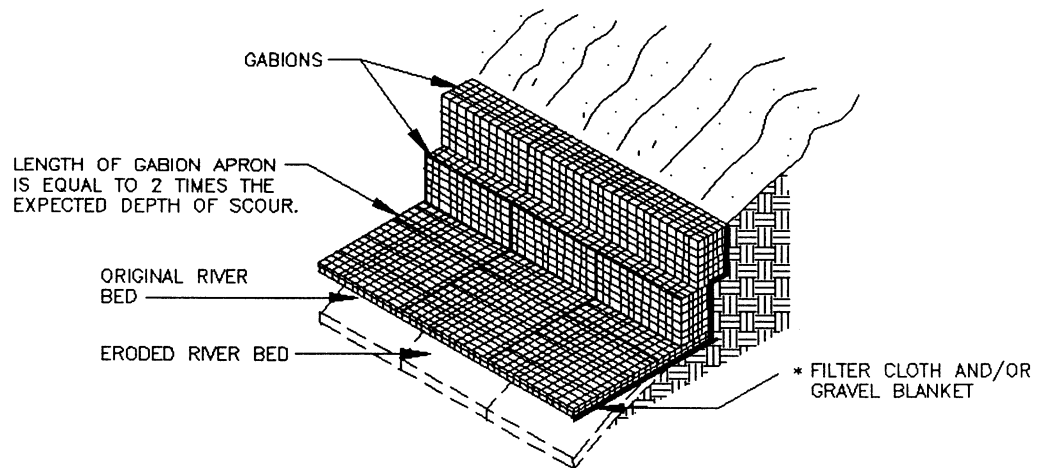
Log Cribbing - a retaining structure built of logs to protect streambanks from erosion. Log cribbing is normally built on the outside of stream bends to protect the streambank from the impinging flow of the stream (see Plate 3.23-3).

Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation. These structures may be obtained in pre-cast blocks or mats, or they may be formed and poured in place. Design and installation should be in accordance with manufacturer's instructions (see Plate 3.23-4).

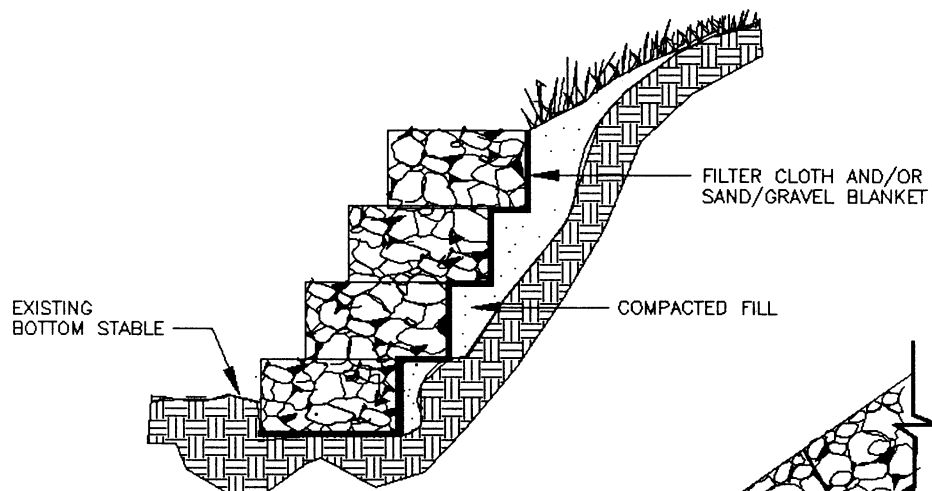
#### Maintenance

All structures should be maintained in an "as built" condition. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank.

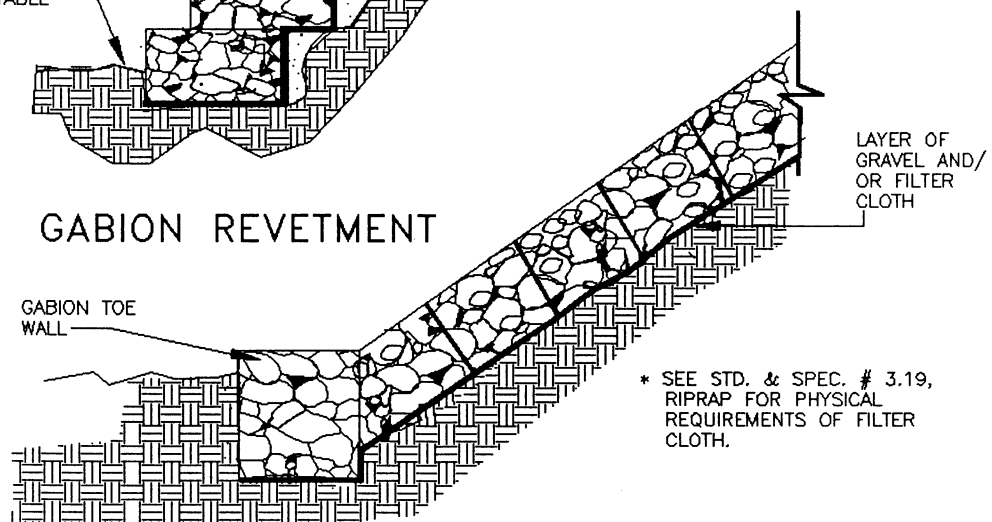
# GABIONS



## GABION TOE WALL



## GABION REVETMENT



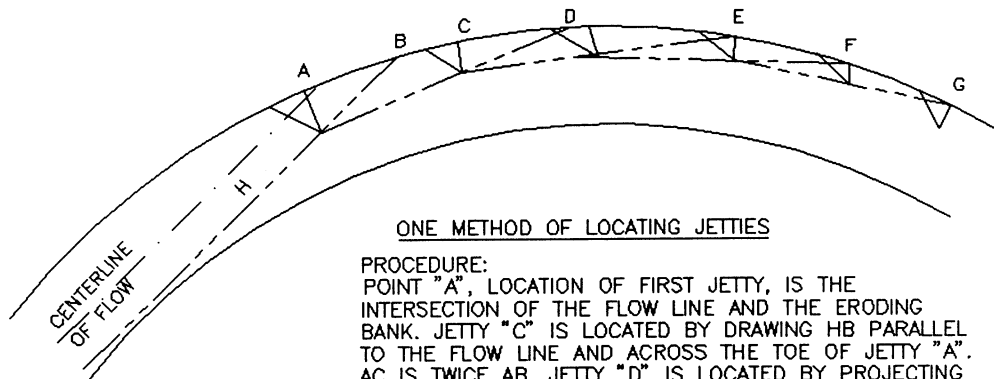
## RENETMATTRESS / RENOMATTRESS

Source: Adapted from product literature of Bekaert Gabions

Plate 3.23-1

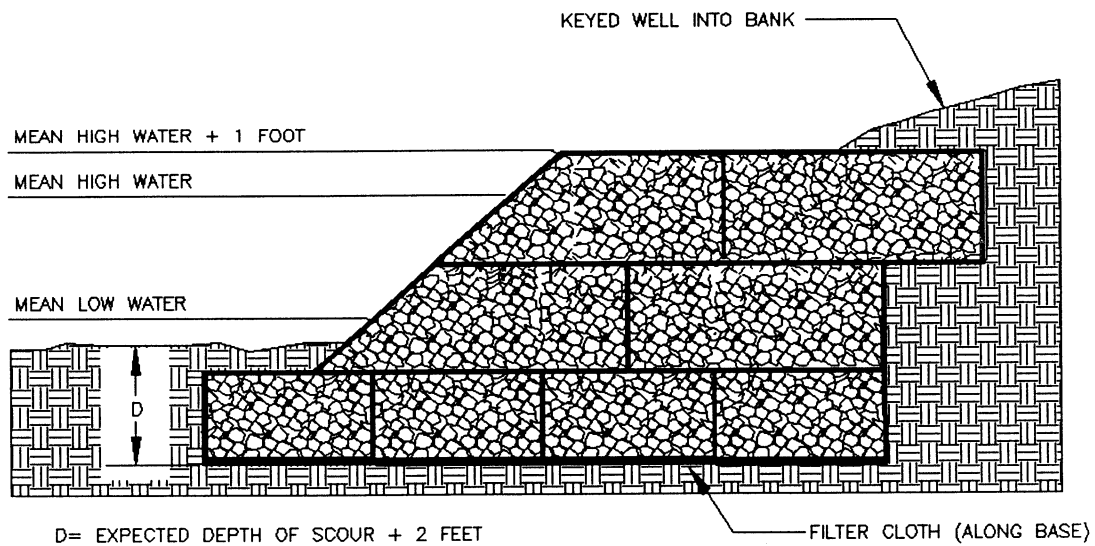


# DEFLECTORS



## ONE METHOD OF LOCATING JETTIES

PROCEDURE:  
POINT "A", LOCATION OF FIRST JETTY, IS THE INTERSECTION OF THE FLOW LINE AND THE ERODING BANK. JETTY "C" IS LOCATED BY DRAWING HB PARALLEL TO THE FLOW LINE AND ACROSS THE TOE OF JETTY "A". AC IS TWICE AB. JETTY "D" IS LOCATED BY PROJECTING A LINE ACROSS THE TOE OF JETTIES "A" AND "C". THE REMAINING JETTIES ARE LOCATED THE SAME AS "D". SUPPLEMENTARY JETTY "K" IS LOCATED AC DISTANCE UPSTREAM FROM "A".



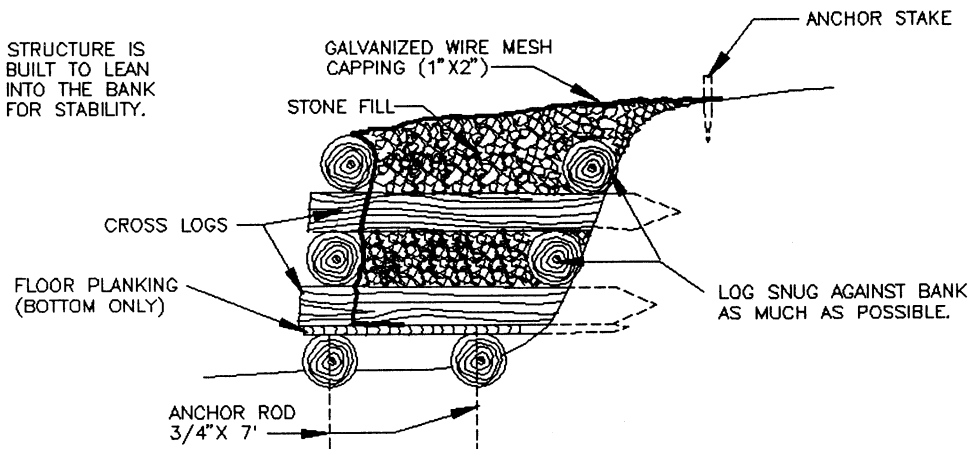
TYPICAL GABION DEFLECTOR

Source: Adapted from product literature of Bekaert Gabions

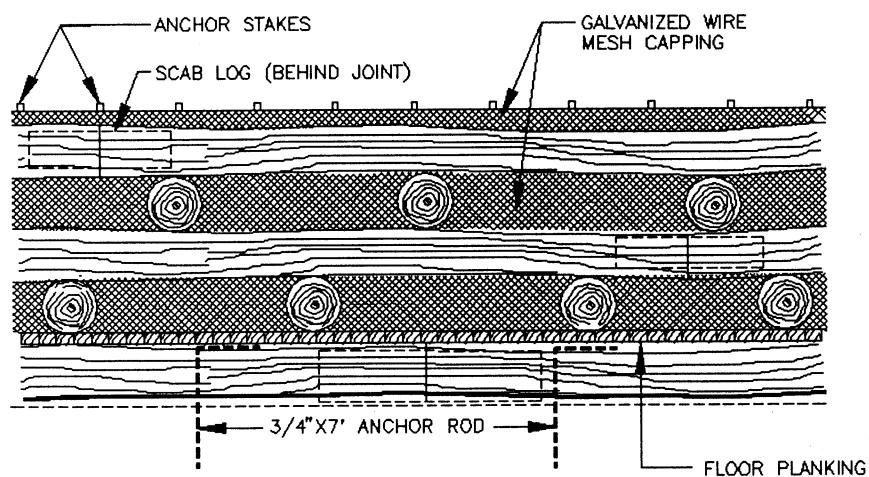
Plate 3.23-2

# LOG CRIBBING

NOTE: STRUCTURE IS BUILT TO LEAN INTO THE BANK FOR STABILITY.



SIDE VIEW

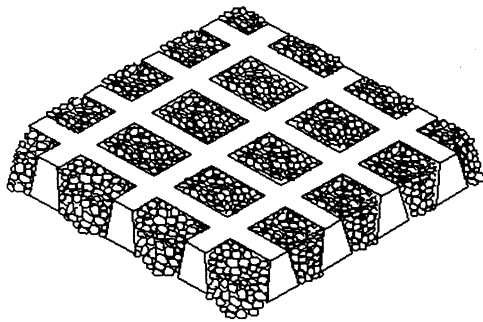


FRONT VIEW

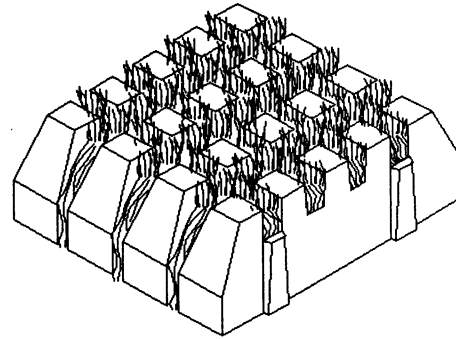
Source: Introductory Guide to Stream Improvement

Plate 3.23-3

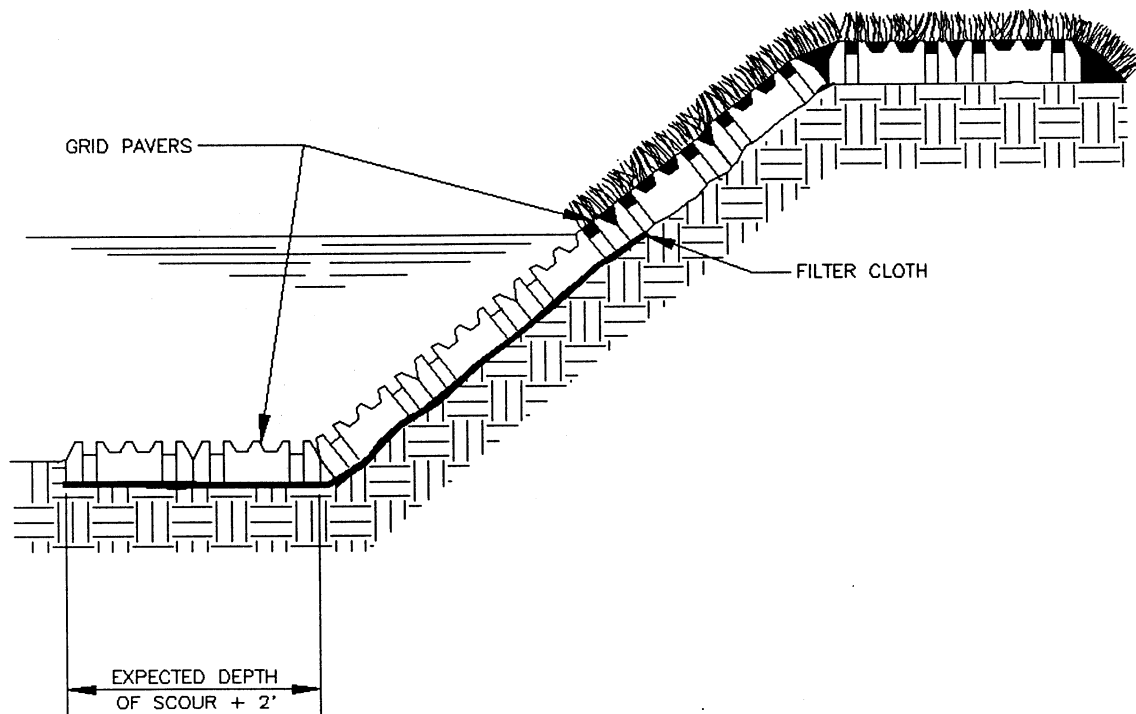
## GRID PAVERS



LATTICE UNIT



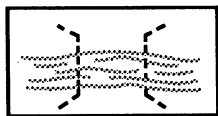
CASTELLATED UNIT



Source: Va. DSWC

Plate 3.23-4

## STD &amp; SPEC 3.24



## TEMPORARY VEHICULAR STREAM CROSSING



### Definition

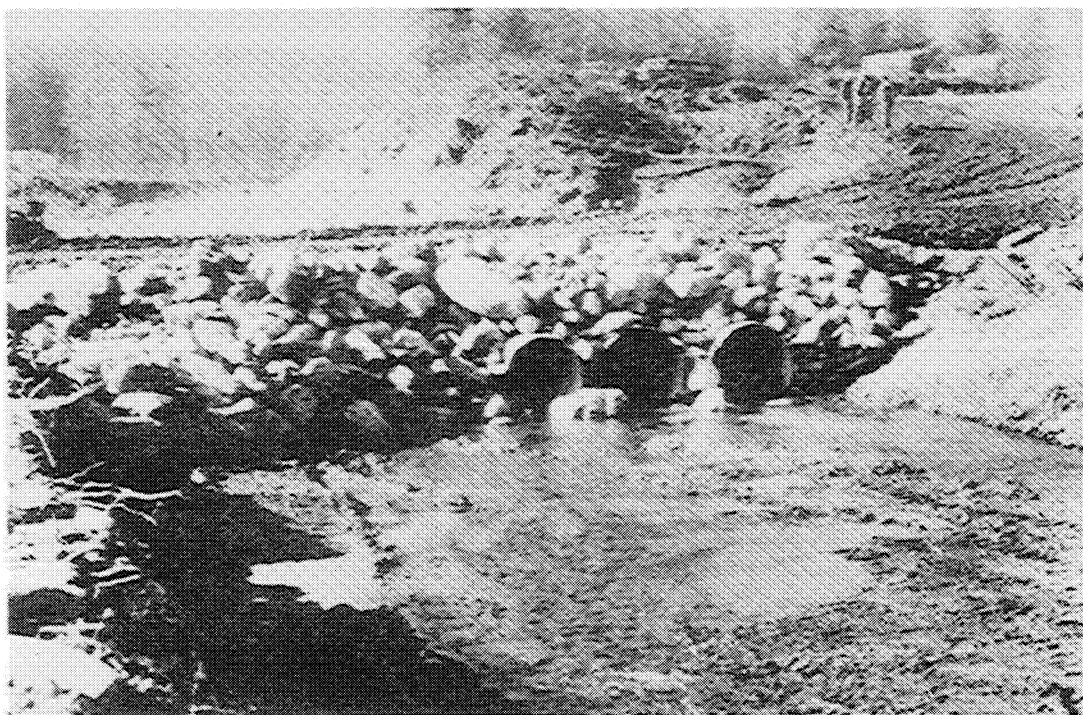
A temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes, pipe arches, or oval pipes.

### Purposes

1. To provide a means for construction traffic to cross flowing streams without damaging the channel or banks.
2. To keep sediment generated by construction traffic out of the stream.

### Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than 1 square mile. Structures which must handle flow from larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.



### Planning Considerations

Temporary stream crossings are necessary to prevent construction vehicles from damaging streambanks and continually tracking sediment and other pollutants into the flow regime. These structures are, however, also undesirable in that they represent a channel constriction which can cause flow backups or washouts during periods of high flow. For this reason, the temporary nature of stream crossings is stressed. They should be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

The specifications contained in this section pertain primarily to flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the span is capable of withstanding the expected loads from heavy construction equipment which will cross the structure. The designer must also be aware that such structures are subject to the rules and regulations of the U. S. Army Corps of Engineers for in-stream modifications (404 permits).

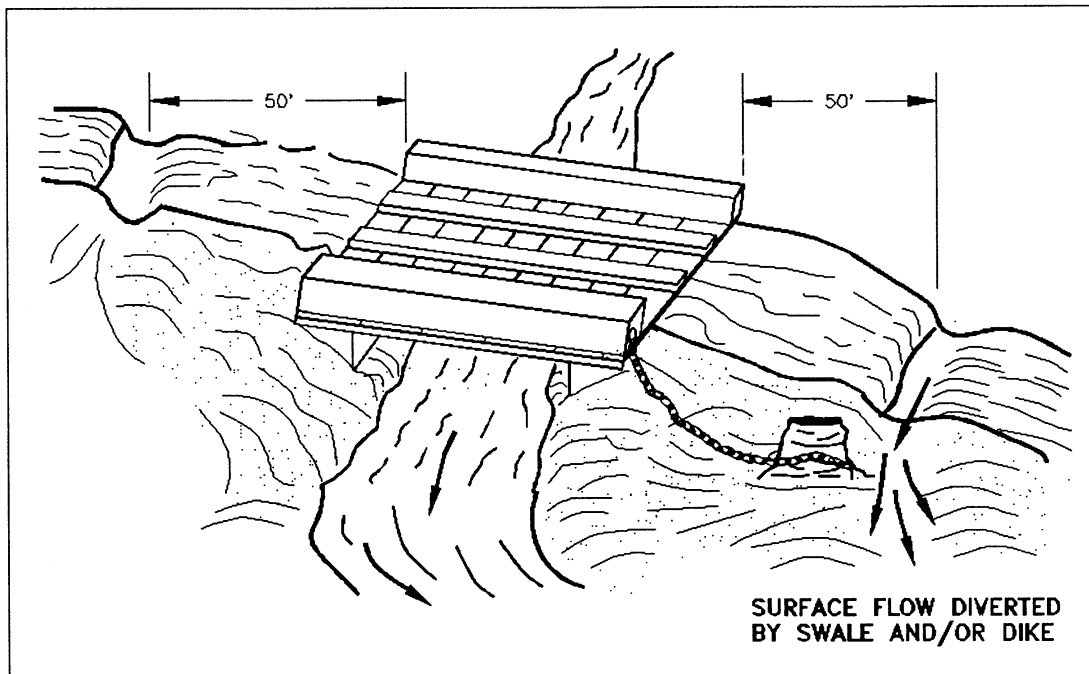
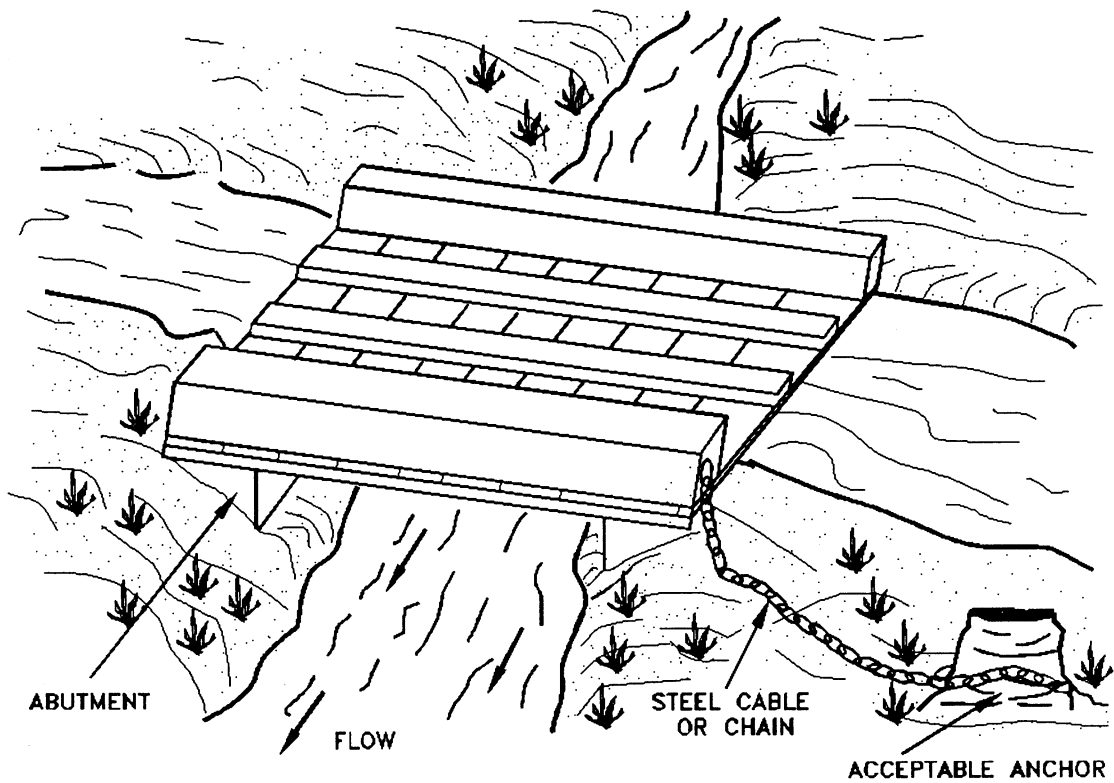
A temporary bridge crossing is a structure made of wood, metal, or other materials which provides access across a stream or waterway. It is the preferred method for temporary waterway crossings. Normally, bridge construction causes the least amount of disturbance to the stream bed and banks when compared to the other types of crossings. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings. A temporary culvert crossing is a structure consisting of stone and a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossings. Temporary culverts are used where the channel is too wide for normal bridge construction or the anticipated loading of construction vehicles may prove unsafe for single span bridges. There is some disturbance within the stream during construction and removal of the temporary culvert crossing. The stone, along with the temporary culverts, can be salvaged and reused.

### Design Criteria

#### 1. Temporary Bridge Crossing

- a. Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand the anticipated loading of the construction traffic. Plate 3.24-1 shows an example of such a crossing.
- b. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the center line of the stream at the intended crossing location.

## TEMPORARY BRIDGE CROSSING



Source: 1983 Maryland Standards and Specifications  
for Soil Erosion and Sediment Control

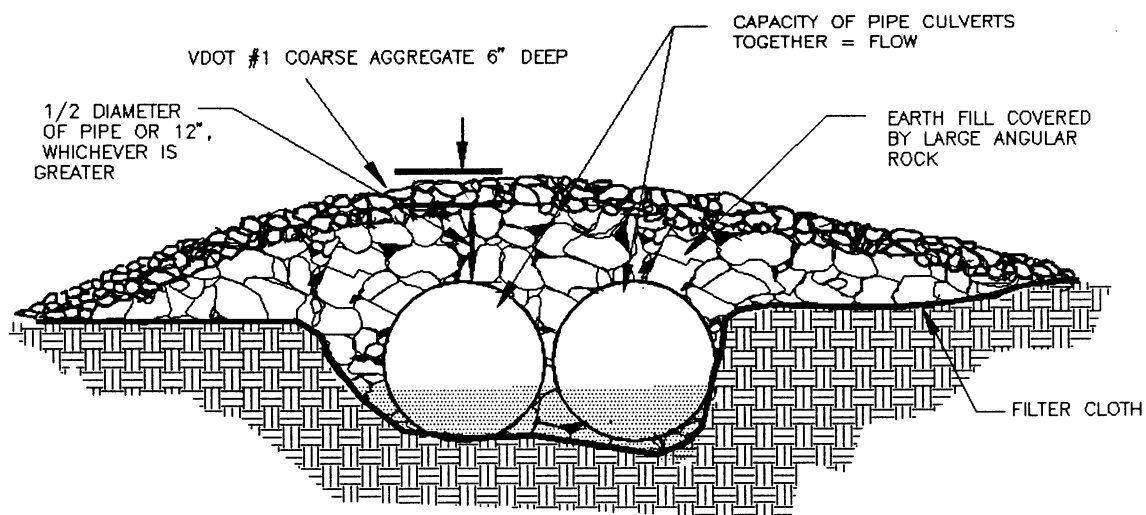
Plate 3.24-1

- c. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.
- d. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Std. & Spec. 3.11, TEMPORARY RIGHT OF WAY DIVERSION or Std. & Spec. 3.09, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.
- e. Appropriate perimeter controls such as SILT FENCE (Std. & Spec. 3.05) or TURBIDITY CURTAIN (Std. & Spec. 3.27) must be employed when necessary along banks of stream parallel to the same.
- f. All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.
- g. Further design/construction recommendations for temporary bridge construction may be found in Construction Specifications.

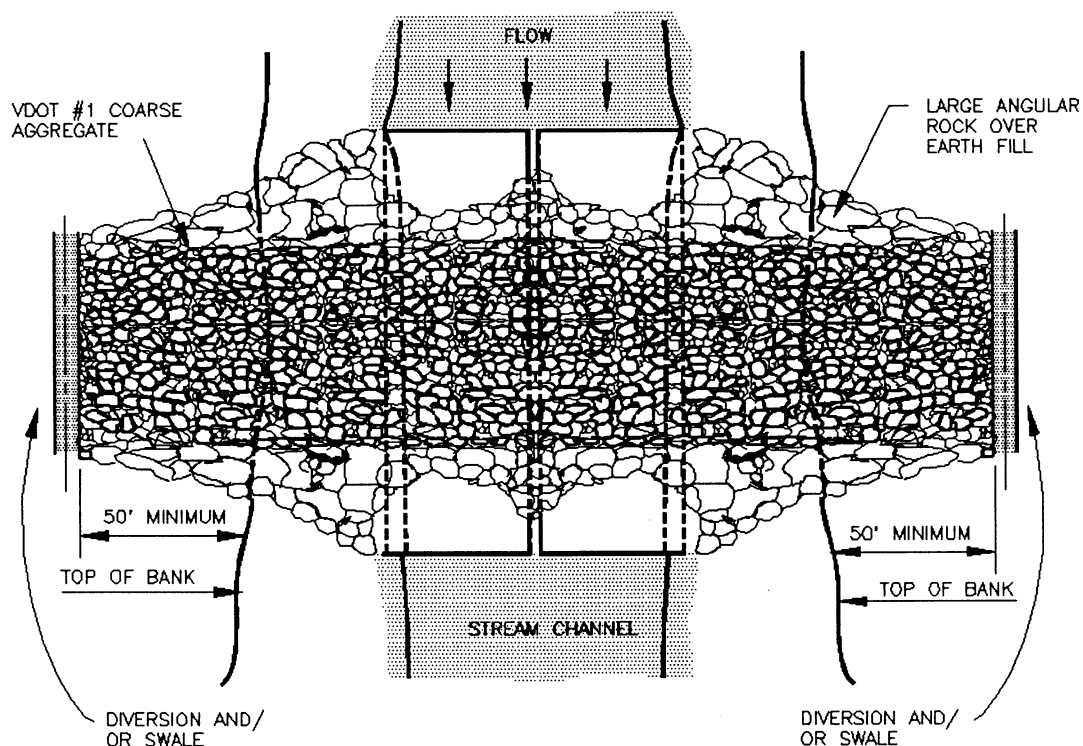
## 2. Temporary Culvert Crossing

- a. Where culverts are installed, VDOT #1 Coarse Aggregate or larger will be used to form the crossing. The depth of stone cover over the culvert shall be equal to one-half the diameter of the culvert or 12 inches, whichever is greater. To protect the sides of the stone from erosion, riprap shall be used and designed in accordance with Std. & Spec. 3.19, RIPRAP (see Plate 3.24-2).
- b. If the structure will remain in place for up to 14 days, the culvert shall be large enough to convey the flow from a 2-year frequency storm without appreciably altering the stream flow characteristics. See Table 3.24-A for aid in selecting an appropriate culvert size (note all assumptions). If the structure will remain in place 14 days to 1 year, the culvert shall be large enough to convey the flow from a 10-year frequency storm. In this case, the hydrologic calculation and subsequent culvert size must be done for the specific watershed characteristics. If the structure must remain in place over 1 year, it must be designed as a permanent measure by a qualified professional.

## TEMPORARY CULVERT CROSSING



ELEVATION



PLAN VIEW

Source: Va. DSWC

Plate 3.24-2



- c. Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 18 inches.
- d. All culverts shall be strong enough to support their cross-sectioned area under maximum expected loads.
- e. The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.
- f. The slope of the culvert shall be at least 0.25 inch per foot.
- g. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the centerline of the stream at the intended crossing location.
- h. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.
- i. The approaches to the structure shall consist of stone pads meeting the following specifications:
  - 1) Stone: VDOT #1
  - 2) Minimum thickness: 6 inches
  - 3) Minimum width: equal to the width of the structure
- j. A water diverting structure such as a swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Std. & Spec. 3.11, TEMPORARY RIGHT OF WAY DIVERSION or Std. & Spec. 3.09, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

**TABLE 3.24-A  
PIPE DIAMETER (INCHES) FOR STREAM CROSSINGS<sup>a</sup>**

Drainage Area (Acres)	Average Slope of Watershed			
	1%	4%	8%	16%
1 - 25	24	24	30	30
26 - 50	24	30	36	36
51 - 100	30	36	42	48
101 - 150	30	42	48	48
151 - 200	36	42	48	54
301 - 350	42	48	60	60
351 - 400	42	54	60	60
451 - 500	42	54	60	72
501 - 550	48	60	60	72
551 - 600	48	60	60	72
601 - 640	48	60	72	72

<sup>a</sup> Note: Table is based on USDA-SCS Graphical Peak Discharge Method for 2-year frequency storm event, CN = 65; Rainfall depth = 3.5 inches (average for Virginia).

Source: Va. DSWC

### Construction Specifications

1. Temporary Bridge Crossing (see Plate 3.24-1)
  - a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

- b. The temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.
- c. Abutments shall be placed parallel to and on stable banks.
- d. Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 feet (as measured from top-of-bank to top-of-bank), then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 8-foot width of the channel. No footing, pier or bridge support, however, will be permitted within the channel for waterways which are less than 8 feet wide.
- e. Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.
- f. Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.
- g. Run planking (optional) shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.
- h. Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.
- i. Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.
- j. All areas disturbed during installation shall be stabilized within 7 calendar days of that disturbance in accordance with MS #1.
- k. When the temporary bridge is no longer needed, all structures including abutments and other bridging materials should be removed immediately.
- l. Final clean-up shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside flood plain of the stream. Removal of the bridge and clean-up of the area shall be

accomplished without construction equipment working in the waterway channel.

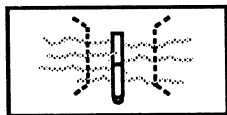
## 2. Temporary Culvert Crossing

- a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.
- b. The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration.
- c. Filter cloth shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum of six inches and a maximum of one foot beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability. See Std. & Spec. 3.19, RIPRAP, for required physical qualities of the filter cloth.
- d. The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.
- e. The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used, they shall be separated by at least 12 inches of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall conform with the aggregate requirements cited in part "i" under "Temporary Culvert Crossing."
- f. When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed. Removal of the structure and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.
- g. Upon removal of the structure, the stream shall immediately be shaped to its original cross-section and properly stabilized.

### Maintenance

Both structures shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

## STD &amp; SPEC 3.25

UTILITY STREAM  
CROSSINGDefinition

A strategy for crossing small waterways when in-stream utility construction is involved.

Purposes

1. To help protect sediment from entering the stream from construction within approach areas.
2. To minimize the amount of disturbance within the stream itself.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than one square mile. Structures or methodology for crossing streams with larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

*A Diversion Channel*  
may be utilized to allow  
"work in the dry".



### Planning Considerations

Utility construction, by virtue of its sprawling, linear nature, frequently crosses and impacts live streams. There is a potential for excessive sediment loss into a stream by both the disturbance of the approach areas and by the work with the stream-bed and banks.

It is often a difficult task to decide what type of control to use as a utility stream crossing. A method such as the "boring and jacking" of pipe below a streambed, which would prevent disturbance within the watercourse, is a preferred method if it is practical. However, in cases where in-stream work is unavoidable, consideration must be given to providing adequate mitigation of sediment loss while minimizing the amount of encroachment (MS #12) and time spent working in the channel. There is some "give and take" as far as the installation of controls - sometimes there is less damage to the environment created by providing substantial controls for the approach areas and refraining from installing extensive measures in the stream itself. However, when the installation of the utility line within streambed and banks will take an extended period of construction time, consideration should be given to substantial in-stream controls or stream diversion in order to prevent excessive sedimentation damage.

As a result of the difficulty in choosing the right method for a utility stream crossing, designers and plan reviewers should always make site visits of proposed crossing to ensure that the most appropriate method is chosen. The designer and plan reviewer should also be aware that such modifications are subject to other state and federal construction permits.

The following are several methods for dealing with utility stream crossings (with varying construction time and stream size scenarios) which allow for "work in the dry" to prevent excessive sedimentation damage. By no means are these methods all-inclusive. As with other control measures, site-specific design and innovative variations are encouraged.

### Design Criteria (All methods)

1. The drainage area should be no greater than one square mile (640 acres).
2. All filter cloth used in the construction of the utility crossing must conform to physical requirements noted in Std. & Spec. 3.19, RIPRAP.
3. Water diverting structures should be used at all trenching and/or construction road approaches (50 feet on either side of the crossing) as per Std. & Spec. 3.24, VEHICULAR STREAM CROSSING.
4. Design criteria more specific to each particular crossing can be found in Plates 3.25-1 through 3.25-4.

### Construction Specifications

1. Diversion Channel Crossing - Preferred method if construction will remain in area of stream for an extended period (longer than 72 hours) and site conditions (such as width of stream) make diversion practical.
  - a. The diversion channel crossing must be operational before work is done in the stream (construction will be performed "in the dry").
  - b. Minimum width of bottom shall be six feet or equal to bottom width of existing streambed, whichever is less. Refer to Plates 3.25-1 and 3.25-2.
  - c. Maximum steepness of side slopes shall be 2:1. Depth and grade may be variable, dependent on site conditions, but shall be sufficient to ensure continuous flow of water in the diversion.
  - d. There are three types of diversion channel linings which can be used, based upon expected velocity of bankfull flow. Refer to Plate 3.25-2 and the following table:

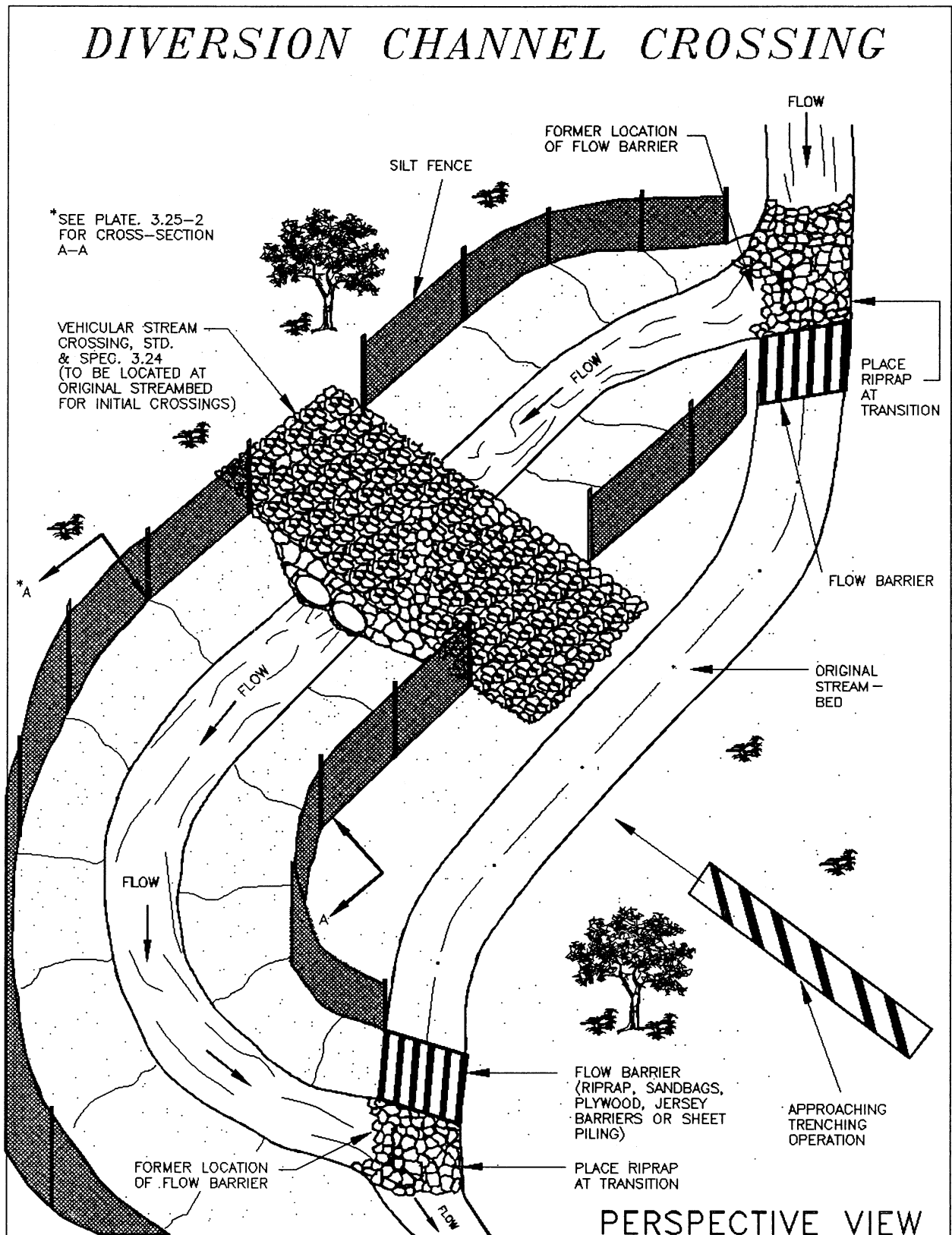
**TABLE 3.25-A**

#### **DIVERSION CHANNEL LININGS**

<u>Lining Material</u>	<u>Classification</u>	<u>Acceptable Velocity Range</u>
Filter Cloth*, Polyethylene or Grass	TYPE A	0 - 2.5 f.p.s.
Filter Cloth*	TYPE B	2.5 - 9.0 f.p.s.
Class I Riprap and Filter Cloth*	TYPE C	9.0 - 13.0 f.p.s.

\* Filter Cloth must meet the minimum physical requirements noted in Std. & Spec. 3.19, RIPRAP.

Source: VDOT Standard Sheets



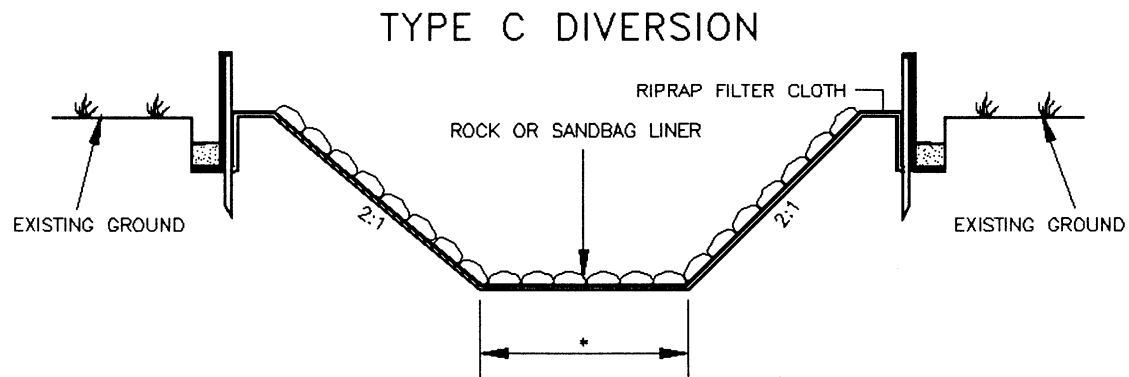
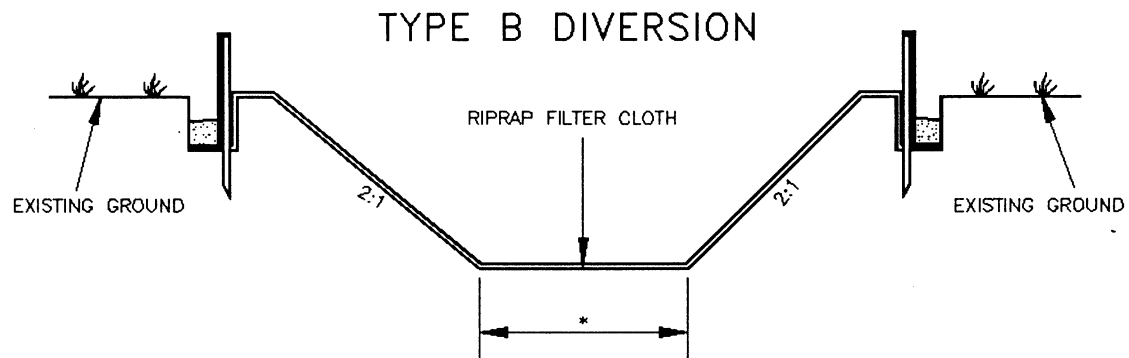
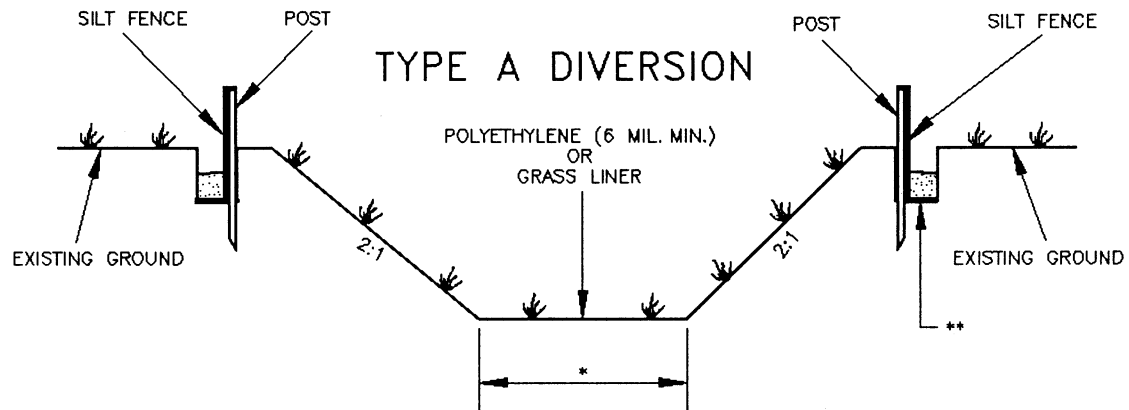
Source: Va. DSWC

Plate 3.25-1



# *DIVERSION CHANNEL CROSSING*

## ACCEPTABLE LININGS (CROSS SECTION A-A OF PLATE 3.25-1)



\* 6' MINIMUM OR WIDTH OF EXISTING STREAM WHICHEVER IS LESS

\*\* ENTRENCH SILT FENCE AND FILTER CLOTH IN SAME TRENCH

Source: Adapted from VDOT Standard Sheets

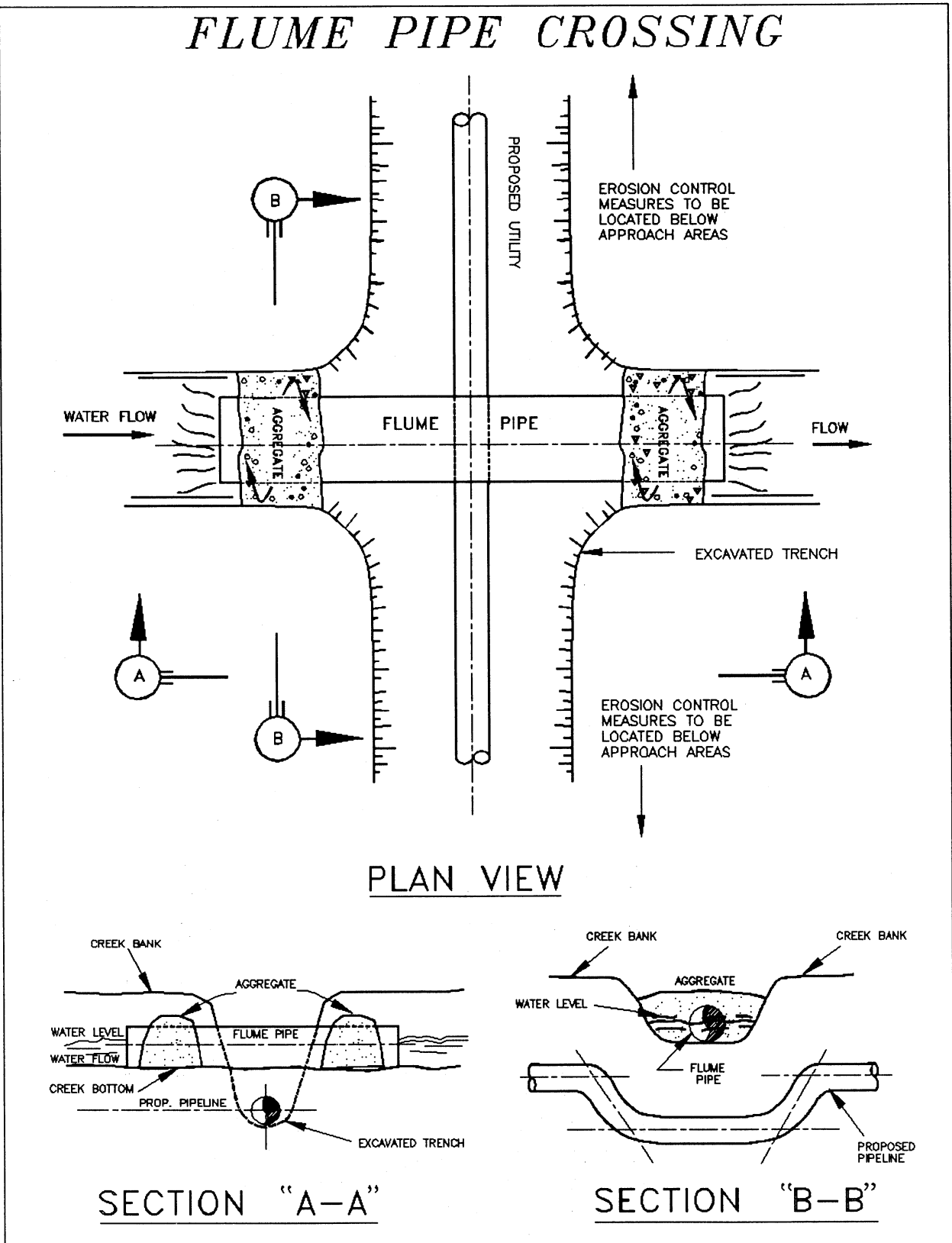
Plate 3.25-2

- e. Type A stream diversions may be seeded with a standard seed mix for the type of soils encountered and the time of year seed is sown. An average growth of two inches in height shall be achieved throughout the diversion with an 85% cover before water is turned through it.
- f. Stream diversion liners shall be secured at the upstream and downstream sides with non-erodible weights such as riprap. These weights shall allow normal flow of the stream. Soil shall not be mixed in with stream diversion weights. Weights may also be needed along the stream diversion's length to secure liner.
- g. Stream diversion liners should be overlapped when a single or continuous liner is not available or is impractical. Overlaps should be such that continuous flow of the stream is maintained. An upstream section should overlap a downstream section by a minimum of 18 inches. Overlaps along the cross-section should be made such that a liner is placed in the stream diversion bottom first and additional pieces of liner on the slopes overlap the bottom piece by a minimum of 18 inches.
- h. Stream diversion liners shall be entrenched at the top of the diversion slopes (slopes breaks) along with a line of silt fence. Silt fence may be excluded if the diversion liner is extended to such a point that siltation of the stream will not occur. If silt fence is excluded, the diversion liner must be secured. Liners shall extend from slope break to slope break as shown in Plate 3.25-2.
- i. Staples used in securing SOIL STABILIZATION BLANKETS AND MATTING (see Std. & Spec. 3.36) or non-erodible weights (riprap) shall be used as necessary to anchor stream diversion liners to the side slopes of the diversion. Wooden stakes should not be used on the diversion's bottom or side slopes.
- j. Non-erodible materials such as riprap, jersey barriers, sandbags, plywood, or sheet piling, shall be used as flow barriers to divert the stream away from its original channel and to prevent or reduce water backup into a construction area.
- k. The downstream flow barrier is to be removed prior to the upstream barrier when opening a stream diversion for the transport of water.
- l. Streams should be rediverted upon completion of the utility crossing for which the diversion was built. Prior to rediversion, any materials (flow barrier) used to prevent water backup into the downstream end of the original streambed shall be removed. This material should not be placed in the downstream end of the diversion until after water has been rediverted to the original waterway. The stream should then be rediverted by removing all of the materials damming the upstream end of the original streambed and then placing it in

the upstream end of the stream diversion. The diversion should be sealed off at the downstream end and then backfilled.

Once started, any work to relocate a stream shall not be discontinued until it is completed.

- m. Stream should be rediverted only after backfilling and restabilization of original streambed and banks is completed. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.
  - n. Any dewatering discharge from this operation shall be placed into an approved DEWATERING STRUCTURE (see Std. & Spec. 3.26).
2. Flume Pipe Crossing - To be used when in-stream construction will last less than 72 hours and stream is narrow (less than 10 feet wide), making "cofferdam" construction impractical.
- a. The flume pipe crossing must be made operational prior to the start of construction in the stream.
  - b. The materials used (culvert(s), stone and filter fabric) must meet the physical constraints of those used in VEHICULAR STREAM CROSSING, Std. & Spec. 3.24.
  - c. A large flume pipe (or culvert) of an adequate size to support normal water channel flow (see Table 3.24-A) shall then be installed in the stream bed across the proposed pipeline trench centerline. VDOT #1 Coarse Aggregate (minimum size) or riprap shall be placed close to each end of the flume pipe so as to dam off the creek forcing the water to flow through the flume pipe (see Plate 3.25-3).
  - d. The entrapped water can then be pumped from the creek within the dammed-off area and in the proposed trench centerline into an approved DEWATERING STRUCTURE (see Std. & Spec. 3.26). The trench can then be dug under the flume pipe. The pipe sections will then be installed to the proper depth under the flume pipe. After pipe sections are installed, the ditch will be backfilled and restabilization shall be carried out.

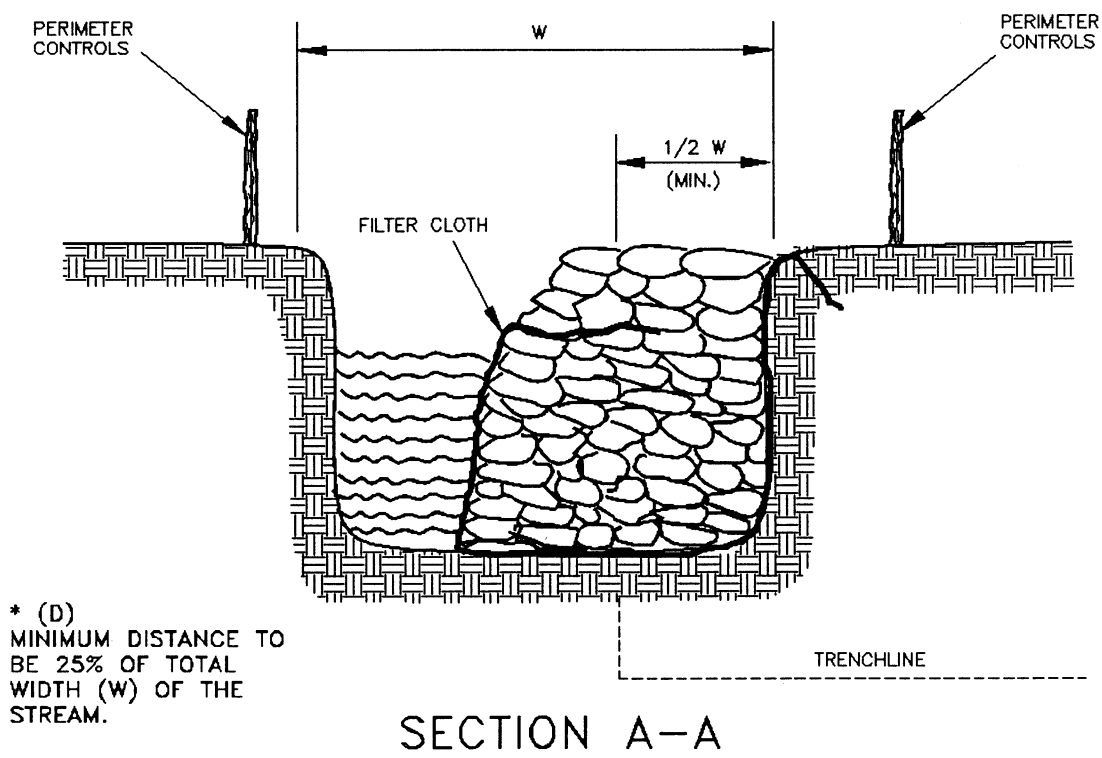
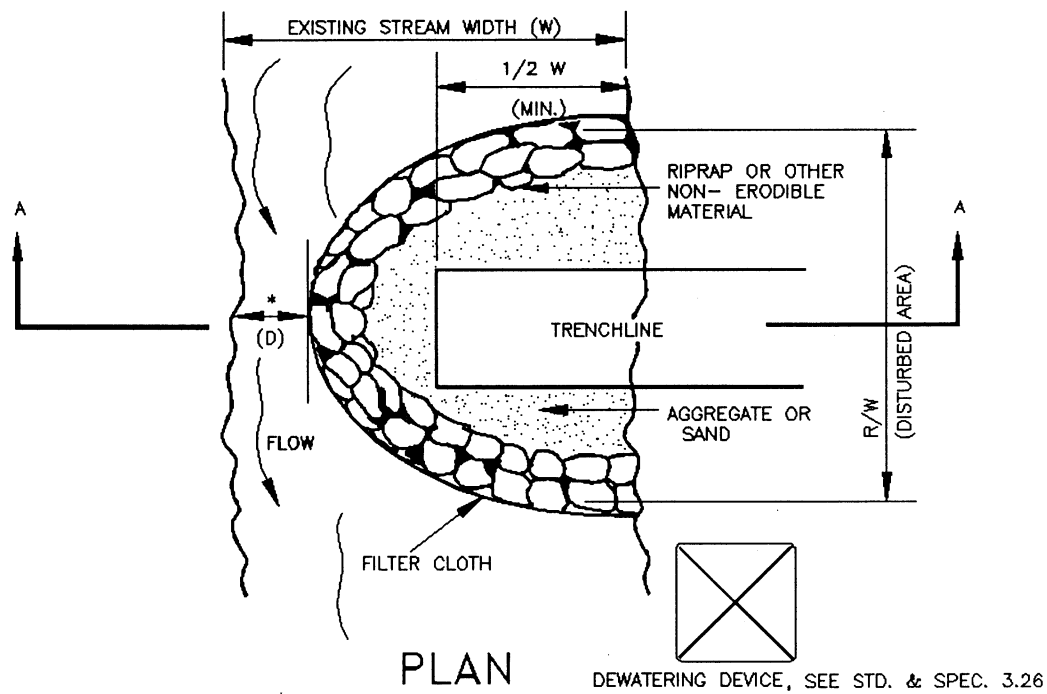


Source: Va. DSWC

Plate 3.25-3

- e. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of the utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.
  - f. After completion of backfilling operation and restoration of stream/creek banks and leveling of stream bed, the flume pipe can then be removed. The gravel can be removed or spread in the stream bed depending on permit requirements. Sediment control in approach areas shall not be removed until all construction is completed in stream/creek crossing area. All ground contours shall be returned to their original condition.
3. Cofferdam Utility Crossing - To be used when stream diversion is not practical and stream is wide enough (10 feet or wider) to make cofferdam installation practical.
- a. Construction is to be performed in low flow periods.
  - b. Crossing shall be accomplished in a manner that will not prohibit the flow of the stream. (See Plate 3.25-4).
  - c. As with all utility line crossings, approach areas must be controlled with perimeter measures such as silt fence or straw bales.
  - d. Remove large rocks, woody vegetation, or other material from the streambed and banks that may get in the way of placing the riprap, sandbags, sheet metal, or wood planks or installing the utility pipe or line.
  - e. Form a cofferdam by placing the riprap (or other non-erodible materials) in a semicircle along the side of the stream in which the utility installation will begin. It must be surrounded and underlain with filter cloth as shown in Plate 3.25-4. The height of and area within the dam will depend upon the size of the work area and the amount of steam flow. Stack materials as high as will be necessary to keep water from overtopping the dam and flooding the work area. When the stream flow is successfully diverted by the cofferdam, dewater the work area and stabilize it with aggregate (VDOT #57 or #68 Coarse Aggregate) or sand. Make sure to discharge the water into a sediment trapping device (see DEWATERING STRUCTURE, Std. & Spec. 3.26).
  - g. Install the utility pipe or line in half the streambed as noted in Plate 3.25-4. Remove the riprap or other materials and begin placing them on the other side of the stream.

# COFFERDAM CROSSING

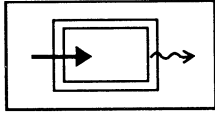


- h. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

#### Maintenance

Care must be taken to inspect any stream crossing area at the end of each day to make sure that the construction materials are positioned securely. This will ensure that the work area stays dry and that no construction materials float downstream.

## STD &amp; SPEC 3.26



## DEWATERING STRUCTURE

Definition

A temporary settling and filtering device for water which is discharged from dewatering activities.

Purpose

To filter sediment-laden water prior to the water being discharged off-site.

Conditions Where Practice Applies

Wherever sediment-laden water must be removed from a construction site by means of pumping.

